

A PARTIALLY ANNOTATED BIBLIOGRAPHY OF
DISTURBANCE, NOISE AND HARASSMENT
EFFECTS ON BIRDS

by

Alex Dzubin

Ecological Assessment Section
Canadian Wildlife Service
Prairie Migratory Bird Research Centre
Saskatoon, Saskatchewan

Update II

May 1984



CANADIAN WILDLIFE SERVICE —

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INTRODUCTION

Increasing demands and pressures of industrial development at high latitudes enhance the frequency of disruptive human activities around traditional bird aggregations. Recently attention has been focused on the reaction of birds (singly or in groups) to the stimuli of aircraft, ship transport and man himself. A high premium has been placed on the protection of environmentally significant areas in the Northwest Territories during the anticipated phase of "balanced development" of hydrocarbon resources. Quantitative assessment of the consequences of man's activities are mandatory if we choose not to endanger the integrity of northern ecosystems and their ornithological fauna. The knowledge necessary to minimize man's impacts will come from well planned and executed research.

A non-exhaustive review of the ornithological literature suggests that aircraft disturbance studies (excluding those on Sonic Booms) have received far less attention than those associated with investigator disturbance. Little information is currently available in refereed journals that clearly and unequivocally documents the effects of increasing noise levels on a variety of bird species over the annual cycle. Furthermore, there is even less documentation of the existing ambient noise levels, machine decibel levels or sound pressure levels associated with changes in bird behavior (Acoustical Society of America 1981; Burger 1983; Grubb 1978).

Reactions of birds to aircraft had been described in the literature as early as 1943 (Carr-Lewty 1943; British Birds 36:151-152) while acknowledgement of the disturbance effects of investigators had been recognized some 8 decades ago by Keading (1903; Condor 5:124-125). Somewhat later, Johnson (1938; Wilson Bull. 50:161-170) documented the complete elimination of a murre colony and associated it with frequent human

disturbance.

In compiling this bibliography I had several objectives in mind:

1. To consolidate available information in order to facilitate access to applicable literature for environmental impact assessment.

2. To focus attention on the importance of studying effects of noise and disturbance and to outline some of the problems and prospects of designing a comprehensive plan to study man's effect.

3. To assess the quality and availability of species studies in order to better define knowledge gaps and fruitful areas for research. To suggest hypotheses for future testing.

4. To develop a field study on noise impacts on seabirds with the following desirable objectives:

- a. To identify those species most vulnerable to noise and the biotic and abiotic factors associated with intolerance.

- b. To identify and quantify aircraft noise levels to which intolerant species react and determine seasonal and environmental changes in tolerance.

- c. To determine at what phase of the breeding cycle seabirds are at greatest risk to mortality from noise related activities.

- d. To develop a system of vulnerability or tolerance indices (viz. 1-10) for aircraft type under a spectrum of breeding and environmental conditions.

- e. To develop a capability to predict the relationships between specific aircraft overflights and mortality increases to age cohorts.

- f. To articulate guidelines and recommendations for airplane overflights over seabird aggregations based on sound, scientifically gathered data.

Due to budgetary and manpower restrictions Objective 4 could not be fulfilled. The other 3 are partially completed but require annual updating.

Guidelines for the temporal restriction of aircraft overflights vertically (up to 1 km) and horizontally (up to 5 km) are already in place for a number of seabird colonies in boreal and Arctic Canada (D.O.T. Aircraft NOTAMS). Field corroboration and biological substantiation of the distance guidelines is now required. Needs encompass precise measurements of a species' reproductive parameters under a spectrum of natural and man-made factors. Aircraft passage, noise and man's activities have all been linked with reduced reproductive output of birds but definitive species studies which show highly correlated cause/effect relationships over the annual cycle are not common.

Primary Literature:

Readers are referred to a number of recent reviews on the subject of investigator disturbance in Anderson and Keith (1980); Bunnell *et al.* (1981); Burger (1981, 1983); Gochfield (1981); Manuwal (1978); Ollason and Dunnett (1980); and Safina and Burger (1983). Those papers gave summaries on the state-of-the-art and introduced antecedent literature. Noise aspects were reviewed in Acoustical Society of America (1981); Bragdon (1979); Chanaud (1974); Dunnett (1977); Fletcher and Busnel (1978); Geist (1975); Grubb (1978); McKnight and Knoder (1979) and Welch and Welch (1970). The National Technical Information Service (1972-1980) published a number of bibliographies on noise effects, primarily on man. Both Blokpoel (1976) and Burger (1983) had encapsulated the problems/solutions of deterring birds at airports. Other major bibliographies are included after the Introductory Section. A number of authors, including Gunn and Miller (1977), Shank (1979), Sopuck, Full, Green and Salter (1979), and Bergerud, Jakimchuck and

Carruthers (1984) had reviewed the literature on northern large mammals and disturbance. Many of the citations contained in those 4 reviews are not included in this report.

Even with the available literature on disturbance and noise, there are apparent major knowledge gaps in the information available to predict impacts on specific bird groups throughout their annual cycle (see RESEARCH NEEDS). Since noise effects are evidently species or group specific, broad inferences extrapolated to other groups are not without error and bias. Specific information on effects of noise on fertility, fecundity, energy budgets, avoidance costs, growth rates of young and survivorship of adults are needed. Under Arctic conditions where unpredictable weather can inject a further constraint measurements seeking cause/effect relationships are particularly cumbersome. Subtle influences, for example the resorption of a follicle or atresia, associated with a noise trauma would be virtually unmeasurable, especially without long term physiological and clutch size measures.

The documentation of all short-term observations of the consequences of any airplane overflights (make, kind, speed, height, weather) over a colonial species during a particular breeding phase has much merit (see Barry and Spencer 1976; Dunnet 1977). Associated measures of noise levels (decibels) or Sound Pressure Levels (Fletcher and Busnel 1978) of aircraft are also required. From a body of such circumstantial evidence hypotheses can be formulated and anecdotal evidence can at least buttress predictions. Any opportunistic observations will become valuable in contracting the confidence intervals of impact projections. It is obvious, however, that convincing and credible predictions will only come from planned experiments and systematic measurements.

Reported Effects:

Resultant effects of noise from man's machines and disturbance by man himself have many similarities considering that there is alarm or fleeing from the stimuli (visual, auditory or vibrational) and avoidance of the source. A partial list of the reported effects of human disturbance and/or "startling" noises includes (1) dislodging of eggs or chicks from breeding ledges during quick escape behaviour of adults, (2) added heat/cold stress leading to higher chick mortality or reduced hatching success of eggs, (3) increased mortality of lost chicks following extreme escape behaviour, (4) colony abandonment or desertion, (5) increased predator losses of eggs or young, (6) killing or injury of transgressing young by other territorial adults, (7) cannibalism by conspecifics, (8) altered parental behaviour leading to lower reproductive output, (9) abandonment of chicks or eggs, (10) artificially increasing density of breeding birds leading to reduced reproductive output, (11) changed social structure of interacting pairs, (12) trampling of eggs and young as a result of pod movement, (13) injuries to wings and dislocation of legs, (14) premature fledging of young leaving cliffs prior to maturity, (15) escape from or avoidance of favored feeding grounds, (16) abandonment of nest scrapes during egg laying, (17) long distance movement of broods and (18) retarded growth of chicks from food deprivation.

Adaptation and habituation to noise and disturbance does occur, but the phenomenon is not well documented for many bird species (Grubb 1978; Parsons and Burger 1982; McNicholl 1973; Kury and Gochfeld 1975; Schreiber 1979; Robert and Ralph 1971). Some species only show minor reaction to noise or human intrusions; generally, man's activities and machine noise reduces breeding success.

Noise and bioenergetics:

Each bird possesses only so much energy in the form of flesh, feather, protein or fat. If energy is channelled to fleeing from a noise or disturbance sources it is not used to incubate eggs, perform territorial pursuits, or subsequently flee from a predator. It is dissipated as activity or heat and lost to the bird. Eating recoups energy but searching for food and eating takes time which could be better used in reproductive activities.

There can only be a finite apportionment among metabolic demanding activities like growth, reproduction, defense and body repair. If through evolution, energy storage tissues within the body are finite in their size, a bird cannot expend much extra energy or continually flee from noise or disturbance without showing a net deficit in the energy remaining for breeding, flying, moulting, or any other maintenance activity. Some other activity loses out, perhaps leading to reduced clutch size, fewer young produced, birds less well suited to long migrations, etc. Such indirect or cumulative reductions in reproductive outputs need quantification. Indirect and subtle losses (difficult to quantify, in a quantity oriented world where "body counts" are all that matters) may well be a global phenomena in today's noise filled world.

Energetic models which described effects of avoidance behaviour by mammals and snow geese had been proposed earlier by Geist (1971), Davis and Wiseley (1974) and Patterson (1974). The present wide use of bioenergetic models as evidenced by the numerous published references in the ornithological literature, reflect well on their utility (see ENERGETIC Sections). Daily energy expenditures and activity budgets have been documented for a number of species but they require further empirical

measurements of metabolic costs (see King 1974 and Kendeigh et al. 1977). Costs of activities such as flight average 10-12 x Basal Metabolic Rate; swimming in ducks, 4 x BMR; brooding, 1.5 x BMR; comfort behaviour, 2 x BMR and hopping and running 3-5 x BMR. Thus fleeing or flying activity away from a noise stimuli could increase energy expenditures up to 10-12 times. Other models have been proposed. The effects of the disturbance by low flying aircraft over White Pelican colonies have been accurately predicted using a simulation model (Bunnell et al. 1981).

Measurement of energy loss from rechannelled activity associated with noise or human disturbance is acknowledged to be difficult to monitor. Indices of enhancement of energy expenditures are suggested by physiological stress responses (Siegel 1980), blood enzyme changes associated with handling, i.e., higher levels of CPK and AST (D. Rainnie, WCVN Saskatoon in litt.) or increased heart beat (Flynn and Gessaman 1979; Jungius and Hirsch 1979; Kanwisher, Williams, Teal and Lawson 1978). An analysis of growth curves of fledgling birds has also been proposed as a potential measure of the effects of environmental stressors (Fendley and Brisbin 1977).

Where food sources are transitory, seasonal, widely dispersed, clumped, or erratic, any interference with the capture, transformation and transmission of energy can only work to the detriment of an individual's survival. The evolutionary success of birds depends on the efficiency with which energy is processed. Maintenance and reproductive bioenergetics of the individual influences all feeding, mating, anti-predation, nesting, brooding and flying behaviour (see Townsend and Calow 1981).

In closing, it is important to underline that inferences based on human activity effects on animals must be tempered with objectivity. For example,

there is a danger in blaming changes in the altered distribution patterns and migratory pathways taken by caribou on man-induced disturbances without parallel consideration of other key factors like predation, low densities and hunting mortality (Bergerud, Jakimchuk and Carruthers 1984). Caribou, like other species, may be adaptable to the presence of humans and their machines. Although appealing, aerial harassment/noise effect correlations may not stand close scrutiny; numbers may also change coincidentally. Thus, cause-and-effect implications may not be warranted. The need for good science and sound experimentation is obvious.

Definitions: (In part after Webster's New Third International Dictionary.)

Harassment is defined as worrying or impeding an animal's "normal" activities, including to tire out, to exhaust or to annoy continually.

Disturbance is associated with a deviation from the norm, an interruption, including to throw into disorder, to agitate, stir up, or to

alarm. A disturbance may be due to the investigator directly or to one of man's many machines. A disturbance may have visual, auditory and vibrational components. Human disturbance (fide Rodgers and Burger 1981) can be separated into non-scientific, which includes recreational activities, habitat modification, vehicular traffic (both air and ground) and presence of pets, while scientific includes the presence of any investigator near a bird. In this report, disturbance does not include habitat alteration which is in itself a major population depressant.

Noise, "sound without value", is used in the context of a notably loud, harsh, incoherent or discordant sound. Any sound that is undesired or interferes with some "normal" activity. An unwanted signal or deviation from a norm which elicits an alarm or fleeing reaction or interferes with communication. Noise can be sudden, e.g., an aircraft appearing suddenly over a cliff or a loud gun report, or anticipatory, e.g., an aircraft approaching a cliff some distance down wind.



MAJOR BIBLIOGRAPHIES AND LITERATURE REVIEWS

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Review in BioScience 34(3):194 by S. Martindale

The Acoustic Sense of Animals is a handsome volume that presents a nontechnical summary of the anatomy, physiology, and measurement of hearing. All the major groups of animals are discussed, although not in uniform detail. Reflecting the author's expertise, mammals are presented by 70 pages, whereas the enormous body of knowledge of birds is summarized in a scant 17 pages. There is very little on field studies of how hearing is used by any of these animals. Nor is there much on neural integration and acoustic pattern recognition by the CNS. But the book is beautifully clear, concise, and informative as a survey of how and what animals can hear and how behavioral biologists measure the ear's performance in the lab.

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RESEARCH NEEDS

NOISE - WILDLIFE

In J. L. Fletcher and R. G. Busnel, 1978: Effects of noise on wildlife. Academic Press Inc., New York. 305 pp.

Summary and Discussion (Pages 303-305)

"Upon completion of presentation of the papers at the symposium, a workshop-round table discussion of the issues and problems associated with noise and wildlife was convened."

"One of the issues raised and addressed was that of coordinating the efforts of the scientist who does research aimed at determining the various effects of noise on wildlife with the various agencies charged with protecting wildlife."

"The experience of EPA has clearly shown the problems involved in going from off the shelf scientific results to formulation of damage risk criteria, then to regulations governing exposure to various potentially hazardous agents. During the course of discussion, the point was made that regulations rather than legislation might be more effective in controlling noise."

"It became clear during the course of the symposium that North America was more concerned about noise and wildlife than any other area. This is not hard to understand when you realize that most of the wildlife in developed countries is found in Canada and the United States. In western Europe, most of the wildlife are primarily concentrated in mountainous areas, national parks and such places. Also, Western Europe is densely populated, much more so than most of the U.S. and Canada."

"Another point that emerged during discussion was that decibels on the A scale (dBA) was not the most appropriate measure to use in dealing with noise levels and their effect upon wildlife. That measure has been most successfully applied to various effects of noise on man, such as hearing loss, annoyance, etc. but it is not appropriate for wildlife for many reasons. It was recommended that sound pressure level (SPL) be used until research pinpoints the most appropriate measure or measures."

"There was some consensus among those present on several aspects of the problem. With regard to research needs, it was generally agreed that there is a critical need for more scientific data. There is not overwhelming evidence that noise is not a significant adverse factor in the life of animals. But neither is there clear definitive data demonstrating that noise is an adverse stimulus or stressor."

"Research needed to answer critical questions in this area would include:

1. Study of individual species, one by one, not only as individual animals, but in social groups (herds, flocks, etc.) such studies

should examine the acoustic nature (frequency, intensity, temporal pattern, etc.) of critical events of the animal (mating, territoriality, alarm, nurture, etc.).

2. More complete knowledge of the spectrum of environmental sound is necessary. Presently, most noise analyses cover only a limited frequency range and do not include areas that could be critical to many animals.
3. We also need to know the effect of noise upon a given animal population that is declining, regardless of why the population is declining.
4. The combined stressor effects of noise with other stresses upon an animal should be studied because of possible potentiation.
5. Both long and short term noise effects must be studied.
6. Studies should include both field and laboratory efforts. Each has merit and neither is sufficient by itself, with each type providing feedback and useful information to the other.
7. Further studies of sound propagation in the field must be done, because this could also be critical."

In Acoustical Society of America, 1981. San Diego workshop on the interaction between man-made noise and vibration and arctic marine wildlife. 84 pp.

RECOMMENDED SCIENTIFIC RESEARCH PLAN

Pages 45-50.

The basic objective of the San Diego workshop was to assess the state of knowledge of the effects of man-made noise and vibration on Arctic marine wildlife, and to recommend a research plan to bring the state of knowledge to a point of adequacy for decision making regarding industrial development and operations in the Alaskan North Slope-Outer Continental Shelf area. On the final day of the workshop the participants developed the elements of a research plan which is presented here in outline form. It is in the form of a five year plan because it was the consensus that five years was likely to be required to provide a reasonably adequate sampling of some of the variables which are season and weather related. It was believed that in many program areas information developed at the end of the first year or two might be definitive enough for some decision-making purposes. In particular, it is likely that an early demarcation may be possible between noise sources of negligible impact and those which may be capable of affecting the wildlife. A priority indicator consisting of a letter and number has been assigned to the elements of the plan. The letter (A, B, C, or D) refers to the urgency of the effort, and the number is an estimate of the time in years required to compile a useful data base for decisions on environmental impact.

Description of Priority Indicator

- A -- Highly important, present data nearly non-existent.
- B -- Important, some data available but inadequate.
- C -- Useful, appreciable data available, more needed to improve confidence.
- D -- Useful, but very difficult to obtain.

Example: A-2-5 Work highly important, significant results expected in two years, five years required for reasonably adequate data base.

Scientific Research Plan

The research needed to guide the assessment of the possible noise and vibration related environmental impacts may be listed under three general areas of approach: (I) direct observation of wildlife, (II) measurement of physical and bioacoustic factors, and (III) analytical predictions based on an analytical model of sound generation, propagation, and animal response. The research plan described below is separated into these three approaches.

I. Direct Observation of Wildlife

A. Natural Environment

This research utilizes skilled observers and statistical procedures to establish baseline data on present animal numbers and distribution in regions of varied, but carefully measured, noise and vibration levels, and by quantitative monitoring determine changes and

trends which might be noise-related.

1. Determine present animal species population and seasonal distribution in selected experimental and control areas, and related noise and vibration levels in these areas. Studies should include seasonal activities, particularly those related to viability of the species or major population groups of the species (mating, denning, pupping, etc.); should estimate normal fluctuation of population with time; and should address the importance of the species to man (subsistence, culture, and aesthetics). A-1-5
2. Conduct a continuing monitoring program of animal populations and noise and vibration in selected areas, and relate to man-made activity and noise. This requires monitoring of noise and vibration in air, water, ice and earth at locations near man-made activity over several seasons. A-2-5
3. Compile anecdotal data from sources to include Native hunters, etc., on effects of industrial-related activity on animals by a systematic program of interviews and questionnaires. B-1-2

B. Experimental Environment

1. Alter the environment experimentally by adding known noise and/or vibration stimuli via carefully controlled playback of recorded sounds or other known stimuli. Compare animal behavior against previously established normal baseline behavior. This is a useful technique to separate effects of acoustical vs. visual or other stimuli. Determine adaptation and habituation responses, and effects of phase of animal behavioral cycle (such as mating, denning, pupping, etc.) in response to acoustic stimuli by long-term observation under experimental acoustic exposure conditions. A-1-5

C. Biology

1. Conduct population studies for various species. Document distribution, variation with time, movement patterns, dependence on other animals (symbiotic relationships, etc.). B-1-5
2. Study the food chain ecology--dependence of various elements of the chain on acoustical factors. Study plankton distribution--possibly use ultrasonic probe technique. B-1-5
3. Refer to Section II-B (Bioacoustics) for additional biological studies with emphasis on acoustical factors.

II. Physical and Bioacoustic Data Needs

The analytic prediction approach uses an analytic model, sometimes called the "source-path-receiver" model, or "sonar equation" to estimate the range of audibility of a given sound. Input data for this

model are level of the source at a known distance (source level), sound propagation data over the path of interest, and detection capability of the receiver (hearing threshold of the animal as a function of frequency). Necessary data are outlined in the following:

A. Physical Acoustics

1. Noise and Vibration Sources

Measure source levels and spectra of all potential industrially related sources; include radiation into all media: air, water, ice, and ground.

- a. Seismic survey equipment (water, ice, earth) A-1-2.
- b. Drilling rigs: Floating, fixed legs, islands A-1-2.
- c. Production platforms: All types A-1-2.
- d. Transportation noise sources B-1-2.

The source measurements above should include the spectrum over the entire frequency range which might affect the biological organisms important to the geographical areas involved, including those in the food chain. Temporal features of the sounds should be measured, including impulsive characteristics, and short-time fluctuations. Long-period effects, such as seasonal and diurnal aspects which might govern operational and sound radiation conditions should be considered.

2. Ambient Noise - Beaufort Sea Area

Measure underwater and airborne ambient noise levels and spectra at locations occupied by animals possibly impacted by noise. These measurements should be planned to produce reliable data on seasonal, diurnal, and weather effects at all locations. Data should include conditions of various ice-cover, ice-dynamics, and bottom type, water depth, and animal activity which may affect biologically generated ambient noise. Measurement program may be of two general types:

- (1) many short period spot checks at various locations A-1-3, and
- (2) long term monitoring at selected fixed locations A-1-5.

3. Sound Propagation - Beaufort Sea Area

Determine sound propagation as function of frequency, season, and weather conditions for selected locations in vicinity of potential noise sources. Investigate propagation in all media: ground or gravel island structure; ice--of various types and thicknesses; water--of various depths, over various bottom types, and under ice of various types; air as propagation medium. Study air-ice-water-bottom interaction related to propagation; particularly determine air to ice to water sound conduction for calculation of underwater penetration of helicopter noise A-2-5.

B. Bio-Acoustics

1. Determine threshold of hearing as a function of frequency for animals of major concern. Studies should include both absolute threshold and masked threshold (critical ratio) to enable prediction of audibility of noise sources under low and high ambient noise conditions: Animals for study--

- a. Bowhead whale
- b. Beluga whale
- c. Ringed seal
- d. Walrus
- e. Others--polar bear, bearded and spotted seals, Arctic fox, various birds, etc.

Research approaches suggested include:

- (1) Behavioral--Laboratory studies employing operant conditioning. Applicable to all except the great whales. B-2-5.
 - (2) Electrophysiological--Study auditory evoked potentials using a mobile laboratory facility capable of rapid transport to site of marine mammal stranding or capture. Applicable to all mammals including the great whales. A-1-5.
 - (3) Comparative Anatomical--Conduct detailed comparative studies of anatomical structure of hearing organs of marine mammals for assessing hearing capabilities for use in auditory detection models. A-1-2.
2. Study sound emission by important species, and functions of sound (communication, echo location, navigation, etc.). Determine frequency range of sound signals and relationship of sound to well being of the species. Determine emitted sound levels to enable estimation of interfering noise levels. Identify calls related to specific behavior such as mating, territoriality, prey-predator relationship, warning, symbiotic relations, communication, identification of individuals, etc. A-1-5.
 3. Study noise as a stressor: Behavioral Studies. Conduct lab and field studies of adaptation of critical species to sound stimuli. Include stimuli of various spectral characteristics and duration. Observe aversive behavior, denial of habitat, dispersal of prey, etc. A-2-5.
 4. Study physiological responses to noise. Laboratory studies of hormonal changes, etc. under noise stimulation, Include noise of various levels, spectral constitution, and duration. D-5.
 5. Determine sensitivity of animals to vibration. Dependence on frequency, axis of vibration, mode of excitation of animal (point of contact, etc.) A-1-5.

III. Analytic Prediction: Calculation of Noise Contours and Estimation of Potential Impact Boundaries

Utilize the data base described under Section II above as inputs to the source-path-receiver analytic model to estimate boundaries of possible noise impacts of various categories as follows:

- A. Initial estimate of maximum impact boundary, beyond which noise is inaudible. Include various combinations of the following elements:

<u>Source</u>	<u>Path</u>	<u>Season</u>	<u>Receiver</u>
Seismic Pulses	Water	Summer	Bowheads
Drilling on gravel island	Gravel-Water	Winter	Beluga
Drilling on platform	Gravel-Ice-Water	Spring	Walrus
Vehicles on ice	Ice-Water	Fall	Seals
Supply boats	Air-Water		
Helicopters	Air-Ice-Water		

Establish scenarios of various combinations of above--calculate maximum audibility range. A-1-5.

- B. Estimate noise impact boundaries of various categories, such as aversive behavior, denial of habitat, dispersal of prey or sub-elements of food chain, etc. D-2-5.
- C. Same as above with inclusion of adaption factor. D-3-5.

Implementation of Research

This research plan involves the interaction of many disciplines and many program elements. It is envisioned that many of the detailed elements and priorities will change with time as indicated by periodic scientific evaluation of the ongoing results using the methodology of Section III A, above. Consequently, it is recommended that the management of the entire program be coordinated among the participating parties and that a multi-disciplinary scientific peer group be established to assist in the review of technical progress and to suggest evolutionary changes in the research plan elements.

It is also important to note that these results will not only provide vital information directly relevant to the Beaufort Sea area, but can be generalized, at least in part, to other areas of concern.

Estimated Cost of Research

It must be recognized that it is exceedingly difficult to estimate the cost of a research effort as broad and interdisciplinary in nature as the one outlined above. The cost of each component may vary widely depending on such factors as number of geographical points sampled, number of species studied, etc. Costs of field studies in the Arctic are especially difficult to predict.

On the final day of the workshop, several members of the writing groups were asked to submit independent estimates of the cost of the five-year research program. The estimates were in general agreement that the effort would be expected to cost approximately thirty million dollars--an average of about six million dollars per year.

Connors, D.G., J.P. Myers and F.A. Pitelka. 1979. Seasonal habitat use by Arctic Alaskan shorebirds. *Studies in Avian Biology* 2:101-111,

Author's Abstract

Shorebirds display a wide range in seasonal patterns of habitat use along the arctic coast near Point Barrow, Alaska. Differences between species reflect habitat preferences, the timing of movements with respect to seasonal habitat availability, and whether the use is breeding, post-breeding, or migrational. During the breeding season (June and July), most activity is centered on the tundra, but by early August a marked coastal movement occurs, resulting in high densities of particular species in shoreline and adjacent habitats. In August and September, widespread use of littoral habitats develops, especially for such species as Red Phalarope, Ruddy Turnstone, and Sanderling. In contrast, Golden Plovers and Pectoral Sandpipers restrict most of their activities to the tundra. Other species exhibit intermediate patterns of habitat use. These patterns determine the dependence of each species on arctic coastal habitats, and the susceptibility of each species to disturbances related to outer continental shelf oil development.

Discussion

"Assessing possible consequences of environmental disturbances requires two general classes of information concerning the nature of the physical disturbance and the ecological features of the area, especially the identity and characteristics of its species. The first of these depends upon collaboration between engineer, physical scientist, and biologist, because it entails not only the physical details of a particular development, but also its probability of occurrence, possible extent in geographic and habitat terms, and its time scale, as well as those of secondary effects. An excellent example of the desired level of collaboration is offered by Weller et al. (1978)."

"The second set of factors are more strictly biological. They rest upon four interacting considerations which must be established for each species: (1) Distribution (2) Habitat use (3) Tropic relationships (4) Social system and behaviour."

"Table 4 estimates relative susceptibilities of the common Barrow shorebirds to disturbances in the littoral zone arising from outer continental shelf oil development. It is based primarily on the patterns reflected in Figure 2: the greater each species' relative use of littoral zone habitat, the more likely it is to be affected by such development. But we have also weighted our estimates with qualitative criteria based on population sizes and the magnitude of concentrations in littoral areas. The result is a somewhat subjective prediction of how likely a species is to suffer adversely from littoral zone oil-related activities in the Barrow area. As such they should provide a useful preliminary guide in management and planning decisions for coastal lowlands near Barrow."

TABLE 4

RELATIVE SUSCEPTIBILITY OF COMMON BARROW SHOREBIRDS TO LITTORAL ZONE
DISTURBANCES

High	Moderate	Low
Red Phalarope	Semipalmated Sandpiper	Golden Plover
Sanderling	Western Sandpiper	Pectoral Sandpiper
Ruddy Turnstone	Baird's Sandpiper	
	Dunlin	
	Long-billed Dowitcher	

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Weller, G., D. Norton, and T. Johnson (eds.). 1978. Environmental assessment of the Alaskan continental shelf, interim synthesis: Beaufort/Chukchi. NOAA Environmental Research Laboratories, Boulder, Colo.

Cummings, W. C. 1981. Bioacoustics considerations. Page 63. In
Acoustical Society of America San Diego Workshop on the interaction
between man-made noise and vibration and arctic marine wildlife.

Author's Abstract

The two major factors in the bioacoustics of the marine mammals and birds under consideration are, (1) sound production as related to animal communication or echolocation, and (2) sound reception, including any adverse noise or signals that may mask other behaviorally important signals or cause harassing, physiological, or psychological harm. A description is given of the known physical features of sounds from bowhead, gray, and beluga whales, ringed and bearded seals, and the walrus. Echolocation is unknown for baleen whales, but it does occur in belugas and perhaps in seals. The sounds of baleen whales are powerful, low-frequency utterances that presumably are used for awareness, courtship, and other relatively simple messages that are capable of being propagated long distances. Audiograms on belugas, ringed seals, sea lions, *Tursiops*, and killer whales are discussed in terms of thresholds, absolute levels, and frequency (Hz). Included are comments on the importance of critical bands and levels. There is an urgent need for audiograms on Arctic species for which no information exists, and for data on hearing capacities in the regions below 500-1,000 Hz. The same need of data exists for sound production and specific and ambient noise sources.

A generalized "sonar" equation is presented in terms of a composite spectral graph including limited absolute data on auditory capacities, animal sound source levels, petro-industrial and Arctic ambient noise levels, and propagation losses. In most cases oil rig noise *per se* may not be very important to these animals, but ships, aircraft, vibrational and other seismic exploratory sounds could have considerable effect on their well being. Associative learning is probably very important--in terms of both acclimation and any harm. The unique experimental design called for in future research will require the innovative development of standardized and rigorous procedures for quantifying noise effects on Arctic animals.

Eldred, K. M. 1981. Defining noise problems for solution. Page 73 in Acoustical Society of America. San Diego Workshop on the interaction between man-made noise and vibration and arctic marine wildlife.

Author's Abstract

This paper reviews the classical source-path-receiver systems model that is used to define and solve noise problems of many kinds. Arctic noise sources include transportation vehicles (aircraft, watercraft, and surface), fixed facilities (oil drilling and production), and seismic exploration activities (air guns and Vibroseis). Little is known of their noise characteristics. The varied and sometimes complex paths involve air, water, ground, and ice, either singly or in combinations. Receivers include a variety of wildlife including whales, fishes, seals, polar bear, and birds. Required mitigation, using standard technology or operational controls, is available for some of the source categories. The most urgent research need is a program that thoroughly documents the noise output from these sources as it radiates along paths of potential importance to the wildlife receivers.

U. S. Federal Council for Science and Technology, 1968. Noise - sound without value. Committee for Environmental Quality. U. S. Gov't Printing office, Washington, D.C. September 1968. 56 p. Reprinted pages 175-189 in *Man's Impact on Environment*, Detwyler, T.R. (ed.) McGraw-Hill Book Co., New York, N.Y. 731 p.

Introduction

"But annoyance is not the only piper we must pay. There is also a price in human health and efficiency. Prolonged exposure to intense noise produces permanent hearing loss. Increasing numbers of competent investigators believe that such exposure may adversely affect other organic, sensory and physiologic functions of the human body. Although by no means conclusive, some evidence indicates that prolonged exposure to intense noise or vibration at ultrasonic frequencies (above the hearing range) as well as at infrasonic frequencies (below the hearing range) also presents a potential threat to health. In short, growing numbers of researchers fear that the dangerous and hazardous effects of intense noise on human health are seriously underestimated. We have no appropriate yardstick yet for measuring the effects of noise on mental health. Repeated or consistent exposure may create stresses of which we are unaware."

"The adverse effects of noise are usually defined in terms of the reactions of the "average person." This concept of the "average person" is interesting and deserves further discussion. It implies that a substantial fraction of the individuals subjected to stress are affected by it in varying degrees."

- * "Noise may affect man indirectly through its effects on domestic animals,
- * wildlife and structures. Available evidence, however, suggests that some
- * animals become habituated to noise very rapidly and exhibit no readily
- * apparent physiological or behavioral changes (5, 6, 7)."

"It is apparent from the foregoing discussion that excessive noise is an undesirable contaminant of our environment. The alleviation of the noise problem is predicted on defining the degree of control we wish to achieve. As in other situations of this nature, a balance must be struck between what we would ultimately like our environment to be and what it presently is. Typically this relationship is established by weighing as many considerations as are available, and arriving at specific limiting levels of contamination. These "standards" then serve as bases for maintaining or improving the quality of our environment."

Occupation Noise

"Aside from hearing loss, noise may cause cardiovascular, glandular, respiratory, and neurologic changes, all of which are suggestive of a general stress reaction. These physiologic changes are produced typically by intense sounds of sudden onset, but also can occur under sustained high level, or even moderately strong noise conditions. Whether such reactions have pathologic consequences is not really known and may be unlikely in view of the body's capacity to adapt to prolonged or recurring forms of sound stimulation including those of fairly high level. However, there are

growing indications, mainly in foreign scientific literature, that routine exposures to intense industrial noise may lead to chronic physiologic disturbances. A German study, for example, has shown a high incidence of abnormal heart rhythms in steel workers exposed to high noise level in their workplaces. Neurological examinations of Italian weavers, also exposed daily to intense noise, have shown their reflexes to be hyperactive. A study reported in the Russian literature shows that workers in noisy ball-bearing and steel plants have a high incidence of cardiovascular irregularities such as bradycardia. Subjective complaints of extreme fatigue, irritability, insomnia, impaired tactile function and sexual impotence also have been made by workers repeatedly exposed to high level industrial noise. All of these disturbances appear marginal in nature and may be difficult to relate causally to noise."

Aircraft Noise

"The rapid growth of the air transportation system has resulted in a wave of public reaction to aircraft noise on and near major airports around the world. The problem also is becoming serious at many smaller airports."

Conclusions and Recommendations

"The noise problem in our environment is increasing. The problem is broad in scope: it affects almost every facet of daily living and not only affects the health and well-being of our citizens but also has broad socio-economic implications."

"Research on noise has been conducted over a long period of time. As a result our technology has reached the stage where, with few but important exceptions, we can cope with almost any indoor or outdoor noise problem provided that we are willing to go to sufficient lengths to do it."

"Unfortunately, the state of our knowledge is such that these lengths frequently are impractical or uneconomic, with the possible exception of building design. Consequently, more information is needed in the application of noise abatement techniques to transportation; building methods and materials; appliance, machinery and equipment design and construction; and the substitution of quiet alternate approaches for noisy methods of accomplishing tasks. Additional information is also needed on the non-auditory effects of noise on humans and animal."

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- Stadelman, William J. 1958. Observations With Growing Chickens on the Effects of Sounds of Varying Intensities. *Poultry Science* 37:776.
- Stadelman, William J. 1958. The Effect of Sounds of Varying Intensity on Hatchability of Chick Eggs. *Poultry Science* 37:166.
- Jeannoutot, Don W. and Adams, John L. 1961. Progesterone vs. Treatment by High Intensity Sound as Methods of Controlling Broodiness of Broad-Breasted Bronze Turkeys. *Poultry Science* 40:517

One of the four "emerging threats" listed in the 1979 "State of the World Environment" report from UNITED NATIONS ENVIRONMENTAL PROGRAM (Nairobi, Kenya) was NOISE. "Noise pollution caused 16,000 people to lose hearing in one year in Sweden alone and has unknown psychological effects on human behaviour". (MAB Communiqué, Canada October 1981. No. 13. Page 5).

[illegible]

AIRCRAFT DISTURBANCE

Barry, T. W., and R. Spencer. 1976. Wildlife response to oil well drilling. C.W.S. Progress Notes No. 67. 14 pp.

Authors' Abstract

The effect of oil drilling on wildlife in the vicinity of the Taglu G-33 site in the Mackenzie River delta was studied during June, July and August 1971. Aerial surveys of wildlife populations within 30 km of the rig site were made and some results compared with those from species surveyed the year before. Numbers and species of birds found in eight selected plots within 2.5 km of the Taglu site and in eight plots of comparable habitat in a control area of similar size 8 km distant were compared. Observations of drilling activities at the rig and of re-supply operations were made in an attempt to isolate disturbing influences.

Of the more abundant bird species, 43% were found to be noticeably less numerous than normal within 2.5 km of the rig during the summer drilling operations, 52% were not affected and 5% (two species) occurred more abundantly. Geese and swans, when moulting, or when in family-group flocks with downy young, moved or stayed more than 2.5 km from the drill rig. Other species apparently became accustomed to activity associated with the rig. Helicopters at low levels were apparently the most disturbing factor, directly affecting a circle of at least 2.5 km radius. Increased predation on nests from which birds were disturbed was an indirect result of their use. The Taglu site was comparatively tidy. Wildlife, such as grizzly bears, was not a problem in drilling activities.

Observations and Results

"Certain species showed signs of adapting to disturbances of rig activities. A ptarmigan roosted on one of the cross-bars of the drilling derrick. Sandhill Cranes, swans and gulls frequently fed within 800 m of the rig site and approached closer as the study progressed. Sandhill Cranes feeding near the rig rarely flushed when fixed-wing aircraft or helicopters passed over them."

"We flew by helicopter from Taglu to Tunumuk and back on June 12 and made the following observations: nesting Glaucous Gulls sat tight on their nests as the helicopter passed over at 90 m; three loons dove as the helicopter passed them; one ptarmigan flushed, and one ran away; and a Sandhill Crane and two large shorebirds flushed. The pilot lowered the helicopter to within 20 m of a nesting Whistling Swan and held that position for a few seconds; the swan did not leave the nest until the helicopter slowly moved to 10 m vertical distance, at which point the swan walked about 3 m from the nest and crouched down. When approached by a man on foot, swans usually leave the nest as soon as the intruder is visible, sometimes when he is as far as 1500 m away.

"We made other helicopter flights at 90 m, following channels to select barge routes and landing sites. During these flights three flocks of Canada Geese

flushed, and Sandhill Cranes leaped off their nests. A flock of about 30 non-breeding swans in a lake sat tight on the water as the helicopter passed over, these birds appeared to be just beginning their moult. We circled down to about 20 m; they continued to sit until we were within 275 m but then swam ashore and started to run. Some tried unsuccessfully to fly away from the helicopter."

"At an altitude of about 90 m the helicopter flew over a flock of 20 moulting adult White-fronted Geese with their young. They remained motionless, the flightless adults with heads and tails up in the defensive posture. The helicopter circled down to about 15 m and moved horizontally to within 12 m of the birds. They made no attempt to use their wings to flop along the water as is their habit when flightless."

"We found that Snow Geese would leave their nests and fly about 0.8-2.4 km ahead of the helicopter when we were travelling at about 150 km/hr at 90 m. The birds began to return to their nests when we were 800 m or more beyond the nest site. Wind direction, as it affected noise, seemed to be a factor in the distance at which the geese left their nests. Resettling on the nests took them up to 45 minutes after our passing, because fights resulted as the disturbed birds crossed the territories of others to regain their own nests. Meanwhile gulls and jaegers took advantage of the geese's absence to prey on the unguarded eggs more heavily than usual. White-fronted geese are not colonial nesters; they use scrub willow for their nest sites, and so are almost impossible to see from the air. However, a few times we saw one bird of a pair, presumably the male, fly from the vicinity of the nest when the helicopter was overhead."

"Non-nesting White-fronted and Snow Geese, generally 1- and 2-year-old birds, frequent the periphery of the nesting areas. They were seen to flush 3 km or more ahead of the helicopter, angling off from our flight path and seldom returning. During the moult the flightless birds run from an approaching boat or low flying aircraft."

Methods

Helicopter = large turbine-powered type.
Survey flights by STOL-equipped Cessna 185.

Barry, T. W., S. J. Barry and B. Jacobson. 1981. Sea-bird surveys in the Beaufort Sea, Amundsen Gulf, Prince of Wales Strait and Viscount Melville Sound - 1980 Season. Unpublished Report CWS-81-003 Library, Can. Wildl. Service Edmonton 69 pp.

Discussion

Page 26-27.

Our coastal surveys for molting seabirds and brood rearing (mostly common eiders) were done in a series to determine when the peak of molt occurs. Weather conditions during each of the surveys was marginal, even for helicopter operations, and the part to the west of Tuktoyaktuk, done with a fixed-wing aircraft, was delayed by persistent rain and fog. The molting flocks were composed mostly of male scaup, white-wing scoter, surf scoter, old squaw, merganser, and occasionally puddle ducks which had migrated for molting to the sea during the first part of July. Observations of scaup and Canada geese on inland lakes and deltas and at Wood and Harrowby bays indicated that the molt migrants arrived only a few days before the molt begins. The flocks were generally bunched by species, but they gave the appearance of mixed flocks from a distance. A noisy aircraft at low level elicited different responses from ducks that served as an aid to identification. Mergansers flopped across the water, scoters dived first as a unit, followed by old squaws; the last to dive, if at all, were scaup and the occasional puddle duck. The species sequence of diving was not reliably consistent and often one or more species were absent from a molting area.

Because of their propensity to dive and because of the inevitable rain, we found it difficult to distinguish surf and white-wing scoters. However, at Numaluk Spit and Herschel Island the impression was that nearly all were surf scoters (see also Vermeer and Anweiler, 1975), while eastward to Harrowby Bay white-wings increased to nearly a 3 to 1 ratio.

In addition to weather conditions, the time of day and tides affected the distribution of molting flocks. Vermeer and Anweiler (1975) confined their observations to "night" at Herschel Island. The birds tended to concentrate along the beaches at night but also concentrate near tide rips. During a three-hour time span the number of sea ducks within a transect along the east side of Nicholson Island (Wood Bay) changed by several thousand.

Reference in above:

Vermeer, K. and G. Anweiler. Oil threat to aquatic birds along the Yukon coast. Wilson Bull. 87(4):467-480.

Beaver, R.D. 1980. Breeding behaviour of white pelicans in the Birch Mountains, Northeastern Alberta. Unpubl. M. Sc. thesis Dept. Zoology. Univ. of Alberta, Edmonton. Spring, 1980. 103 pp.

Breeding Population Census (Page 12)

"I chose to census aurally as described by Boeker (1972) rather than by direct visitation to the island; the latter technique could have panicked the incubating adults, incurring damage to nest contents by their flushing or leaving eggs or young exposed to the elements or the predatory habits of California Gulls (*Larus californicus*) (Schaller 1964; Vermeer 1969; Johnson 1976; Johnson and Sloan 1976). At Birch Lake, there were approximately 15 and 25 pairs of California Gulls nesting in association with the pelicans in 1976 and 1977 respectively."

Literature Cited (See Beaver and Lewin (1981) for others)

- Boeker, E.L. 1972. A survey of White Pelican nesting colonies in 1972. *American Birds* 26:24, 125.
- Johnson, R.F. 1976. Mortality factors affecting a White Pelican population, Chase Lake National Wildlife Refuge, North Dakota. Unpubl. M.S.F. thesis, Michigan Technological University. 74 pp.
- Schaller, G.M. 1964. Breeding behavior of the White Pelican at Yellowstone Lake, Wyoming. *Condor* 66:3-23.
- Soper, J.D. 1952. Protection of wildfowl breeding grounds in the Lake Newell locality, Eastern Irrigation District, Alberta. Canadian Wildlife Services, Edmonton. Unpublished report. 26 pp.

Bergerud, A.T., R.D. Jakimchuk and D.R. Carruthers. 1984. The Buffalo of the North: Caribou (Rangifer tarandus) and human development. Arctic 37(1):7-22.

Author's Abstract:

The demography, movement, and behaviour patterns of eight caribou populations (Kaminuriak, Nelchina, Central Arctic, Fortymile, Porcupine, British Columbia, Newfoundland and Snøhetta) exposed to industrial activities or transportation corridors are reviewed. Behaviour patterns of caribou encountering transportation corridors are explainable in terms of adaptive responses to natural environmental features. There is no evidence that disturbance activities or habitat alteration have affected productivity. Transportation corridors have adversely affected caribou numbers by facilitating access by hunters. There are no examples where physical features of corridors or associated disturbances have affected numbers or productivity. Caribou apparently have a high degree of resilience to human disturbance, and seasonal movement patterns and extent of range occupancy appear to be a function of population size rather than of extrinsic disturbance. The carrying capacity of the habitat is based on the space caribou need to interact successfully with their natural predators. Caribou must not be prevented from crossing transportation corridors by the construction of physical barriers, by firing lines created by hunting activity along a corridor, or by intense harassment - a loss in usable space will ultimately result in reduced abundance.

Key words: caribou (Rangifer tarandus), disturbance, wolves, predation, overharvest, access.

Blokpoel, H., and D. R. M. Hatch. 1976. Snow geese, disturbed by aircraft, crash into power lines. *Canadian Field Naturalist* 90:195.

"During the spring migration, the eastern populations of the Snow Goose, *Chen c. caerulescens*, have major staging areas on the prairies of southern Manitoba where they feed and rest (Blokpoel 1974)."

"On 8 May 1974 several thousand Snow and Blue Geese were feeding on a stubble field near Pilot Mound, about 145 km southwest of Winnipeg. The birds covered almost the whole field and some were feeding very close to a power line that bordered one side of the field. A light aircraft flying at an estimated height of 100 to 200 ft. (30 to 60 m) approached the field and caused panic amongst the geese. They took wing and in a chaotic mass rushed off the field on the side of the transmission lines. Many geese were injured or killed because they struck the wires, with the total number of birds involved varying from 25 to 75 depending on the person reporting the incident. It is unknown whether the birds were killed by the impact or from electrocution. The geese broke the wires and caused a local power failure."

"Collisions with wires as a source of anatid mortality have been reported by Harrison (1963) and Cornwell and Hochbaum (1971)."

"There are several reports of Snow Goose disturbance in southern Manitoba by light aircraft. Some of those cases probably involved curious and ill-informed pilots but on other occasions there was deliberate harassment. Apart from disturbing the birds, low-flying pilots run the risk of colliding with one or more geese which could easily break the wind-shield or damage the rest of the aircraft and engines. When making aerial censuses, water-fowl biologists should be aware of the possibility that panicked birds may crash into structures in their attempt to avoid the aircraft."

Literature Cited

- Blokpoel, H. 1974. Migration of Lesser Snow and Blue Geese in spring across southern Manitoba. Part 1. Distribution, chronology, directions, numbers, heights and speeds. *Canadian Wildlife Service Report Series*, Number 28. 29 pp.
- Cornwell, G., and H. A. Hochbaum. 1971. Collisions with wires--a source of anatid mortality. *Wilson Bulletin* 83:305-306.
- Harrison, J. G. 1963. Heavy mortality of Mute Swans from electrocution. *Wildfowl Trust Annual Report* 14:164-165.

Cottureau, P. L. 1978. Effect of sonic boom from aircraft on wildlife and animal husbandry. Pages 63-76 in Effects of noise on wildlife. J. L. Fletcher and R. G. Busnel (eds.) Academic Press, New York.

Conclusion (Pages 75-76)

"It appears that all the domesticated farm and wild animals show behavioural startle when they first experience a sonic boom. Their reaction is usually slight and they seem to adapt readily to further booms."

"Poultry are reported to give the most pronounced responses. It has not been possible as yet, to clearly demonstrate that deaths, injury or loss of production have arisen as a consequence of sonic boom exposure."

"In the early days of supersonic flight a number of claims for compensation for damage to animal enterprises were made, and it now seems settled more for the sake of convenience than as a result of clear-cut evidence."

"The greatest research need is for critical observation of the response of aggregations of various social mammals and birds to sonic booms of measured overpressure and duration. Cooperative research in this area is highly recommended with a large participation of biologists. Concerning wild animals the following statements may be made with a degree of confidence effects upon wild mammals or birds; sonic booms of extreme overpressures (20,000 N/m²) may have the potential to crack bird eggs, but the question awaits an adequate experimental test: chronic, direct effects on wild animals have not been investigated, but no significant effects of this kind are presently foreseen; the disturbance effects of sonic booms of overpressure around 100 N/m² on wild mammals are probably insignificant, but the responses of a much greater diversity of species should be studied. Such booms are markedly more disturbing to birds than to mammals, and, in the case of colonially nesting birds, adverse effects may result from sonic boom exposures."

Davis, R. A., and A. N. Wiseley. 1974. Normal behaviour of Snow Geese on the Yukon-Alaska North Slope and the effects of aircraft-induced disturbance on this behaviour. September 1973. Arctic Gas Biological Report Series 27(2). 85 pp.

Authors' Abstract

During September, large numbers of snow geese (up to 400,000) congregate on the North Slope of Yukon and Alaska where they accumulate energy reserves to fuel their fall migration. These geese are potentially susceptible to disturbance by aircraft overflights.

This study was designed to document normal (i.e. undisturbed) behaviour of snow geese during staging, and evaluate the effects of overflights by various types of aircraft upon this behaviour. The ability of snow geese to accommodate to increased disturbance was assessed.

In September 1973, observations of snow geese were made at five camps along the North Slope. The behaviour of undisturbed geese was documented during 663 hours of observations on over 175 flocks. The behaviour of geese during 73 natural disturbances and 163 non-experimental aircraft overflights was observed. Experimental overflights at two hour-and-a-half intervals using a small fixed-wing aircraft (Cessna 185) and a small helicopter (Bell 206-B) were used to assess the reactions of snow geese to accommodate to an increased frequency of disturbance.

Undisturbed snow geese spent 57% of daylight hours feeding. For the juveniles alone this figure was 65-70%.

Flocks of snow geese were equally prone to flush in response to fixed-wing aircraft and helicopters. They flushed at greater distances from helicopters, but flew for a longer time and exhibited longer overall interruption of normal behaviour in response to fixed-wing aircraft. Snow geese accommodated to a varying extent to increased frequencies of overflights by small fixed-wing aircraft and helicopters.

Non-experimental aircraft disturbances averaged 0.25 per daylight hour. These resulted in a potential decrease of 2.6% in time spent feeding. Experimental overflights at two hour intervals by fixed-wing aircraft produced more severe reactions. These caused an 8.5% decrease in feeding time, and could cause a reduction of 20.4% in the energy reserves that juvenile geese can acquire on the North Slope in preparation for migration. The corresponding figure for overflights by small helicopter is a possible reduction of 9.5%. These potential decreases are dependent upon the extent of accommodation and the ability to increase overall feeding efforts.

Experimental Overflights

"Aircraft were flown along prearranged flight paths at an altitude of 500 feet over Blow River and Shingle Point. On September 14, a Cessna 185 was used to overfly Shingle Point at half-hour intervals and Blow River

at two-hour intervals. On September 16, a Bell 206-B helicopter followed the same program."

"The two-hour interval was chosen to provide controlled data on the reactions of flocks of snow geese to disturbances. This frequency is in the same order of magnitude as the current level of aircraft disturbance in these areas (0.38 flights/hr at Shingle Point as measured in this study)."

"Overflights at half-hour intervals were used to test the reactions of snow geese to increased levels of disturbance. These experiments were attempted to determine if geese reacted with greater or lesser intensity to increased disturbance. A lesser response would imply accommodation."

Reaction to Non-Experimental Aircraft

"The behaviour of flocks of snow geese in response to overflights by non-experimental aircraft was recorded. Observers attempted to obtain the following information about each overflight:

- (a) source of disturbance
- (b) horizontal distance between aircraft and flock when behaviour changed
- (c) altitude of aircraft
- (d) behaviour of flock before, during and after each incident, including duration of behaviour changes and distances flown by the geese.

It was not always possible to obtain complete information about every flock since observers often had several flocks under observation at one time."

Classification of Aircraft

"Aircraft were classified according to size. This classification is similar to that described in Section 13(b) 3.2.1 of the application exhibits submitted by C.A.G.S.L. and A.A.G.S.C.:

- (a) Medium Aircraft (Type A): fixed-wing aircraft such as DHC-6 Twin Otter, F-27 and MU-2.
- (b) Small Aircraft (Type B): fixed-wing aircraft such as Cessna 185, Cessna 337, Beaver and Super Cub.
- (c) Large Aircraft (Type C): fixed-wing aircraft such as Hercules, Electra and DC-3.
- (d) Small Helicopter (Type D): helicopters such as Bell 206 and Hughes 500.
- (e) Large Helicopter (Type E): helicopters such as Bell 204, Bell 205, and Bell 212. None of these was recorded during this study.

Effects of Disturbance on Energy Regimes

"When geese fly in response to disturbance, they increase their metabolic rate and are thus using more energy as well as losing potential feeding time."

Hence, estimates of the effects of disturbance based only on the length of interruption underestimate the true effects, which include increased consumption of energy. The rate of energy metabolism while in flight is approximately twelve times that while the bird is at rest (Berger and Hart, 1974)."

"Juvenile geese on the North Slope require a certain amount of energy for maintenance and growth. This amount is relatively fixed and these energy demands must be met before any increases in fat levels (i.e., energy storage) can occur. Thus, disturbances that result in reduced energy intake and increased metabolism directly affect the amount of fat that can be stored."

Literature Cited

- Berger, M., and J. S. Hart. 1974. Physiology and energetics of flight. Pp. 415-477. In D. S. Farner and J. R. King (eds.), Avian biology Vol. 4, Academic Press, Chicago.

Dunnet, G. M. 1977. Observations on the effects of low-flying aircraft at seabird colonies on the coast of Aberdeenshire, Scotland. Biological Conservation 12:55-63.

Authors Abstract

The greatly increased use of helicopters and fixed-wing aircraft to support the exploration and exploitation of oilfields in the North Sea gives rise to concern about possible disturbance to seabirds breeding in the flight paths. The observations reported in this paper were made at a mixed colony of fulmars (Fulmarus glacialis), shags (Phalacrocorax aristotelis), herring gulls (Larus argentatus), kittiwakes (Rissa tri-dactyla), guillemots (Uria aalge), razorbills (Alca torda), and puffins (Fratercula arctica), breeding on the Buchan cliffs about 40 km north of Aberdeen, on two days during egg-laying and early nesting stages of the breeding season.

The number of birds in attendance at nests or nesting ledges were counted before and after the passage of aircraft, and general observations were made when the planes were overhead. The number of identifiable nests with 0, 1 or 2 adults was noted since disturbance might be most sensitively detected by the departure of non-incubating brooding adults.

No evidence was found to suggest that aircraft flying at heights of about 100 m above the cliff-top affected the attendance of incubating and brooding birds, and there was only a slight indication that a few of the "second adults" at kittiwake nests may have flown off. Groups of kittiwakes resting on nearby cliffs or on the sea did take to the air in response to the planes, but they also did so frequently in the course of the day with no obvious cause. It is stressed that these findings cannot be extrapolated to other species of seabirds or to different conditions.

Results

"Kittiwake. Statistical analyses were carried out to determine if there had been any drop in the numbers of birds attending occupied nests as a result of the passage of the aircraft. The most sensitive test seemed to be to compare the proportion of nests with two birds in attendance before and after the passage, and also to compare the numbers of birds at nests and not at nests before and after. These analyses have been carried out in relation to the passage of the Aztec and the helicopter, and the χ^2 values, all clearly not significant, are given in Table 2. Similar analyses for the data on shags give insignificant values of χ^2 in relation to both aircraft passages.

Guillemot. For guillemots we compared the mean number of birds counted on the ledges before and after each flight. In general 150 to 160 birds were counted and the standard deviation was about 10% of this value (Table 1). It is clear from the counts that the passage of the aircraft brought about no detectable difference in the number attending the breeding ledges.

Similar analysis of the data for razorbills also shows no effect from the passage of the aircraft. Data for puffins and fulmars are so few that it is not possible to make any firm conclusion from them, though there was no indication that they were responding in any way to the passage of the aircraft.

General observations(pg 60). As the Aztec circled round first of all, not very low, there was no response. The guillemots which I was watching very carefully did not respond in any way, nor did I see any exodus by kittiwakes or other species from the breeding ledges. When the aircraft came directly over the stack at a height of about 150 m about 10 guillemots and perhaps 15 kittiwakes were seen to leave the cliff but there was no sign of any sort of mass panic. The birds came off mainly from the outside of the stack and were not positively seen to come from the breeding ledges; they may well have been loafing birds. Mr. Mike Wharlington of BP Petroleum Development Ltd., who was travelling in the Aztec, reported that most of the kittiwakes which flew came from an area to the south of the stack and they may well have been loafing birds.

The only obvious response to the passage of the Sikorsky S61 helicopter was that a few kittiwakes were seen to fly away from the far side of the stack. We did not see whether or not they came off nests. There were more kittiwakes than "normal" flying around just after the helicopter passed—probably twice as many—but I have no evidence as to the source of these birds.

During observations on 14 May we saw razorbills, guillemots, herring gulls and kittiwakes copulating on the cliffs. We also saw eggs in the nests of kittiwakes, shags and herring gulls, and the guillemots' eggs on the ledges.

General observations (pg 62). During the course of the observations a number of potentially disturbing influences were noted and reaction of the birds to them was recorded. At 0810h a small helicopter flew past about a mile inland and there was no detectable response among the birds on the cliffs. A little while later two lobster boats came close in under the rocks to lay pots, and these were almost completely ignored by the birds on the cliffs, and possibly by those on the water also. At 1013h one of the large Sikorsky S61 helicopters passed about 1 km to the south of the stack and 1 km out to sea. Two hundred or so loafing kittiwakes sitting on rocks near sea level took off when the machine was still a considerable distance away and certainly before they had seen it. Since there was a similar panic of kittiwakes just before this, it is very difficult to know whether or not the birds were responding to the helicopter. At 1110h the herring gull roost in the nearby field at the cliff top took off, possibly in response to someone walking on the cliff top at considerable distance. As they went off calling, the kittiwakes which had been gradually reassembling on the low rocks also took off. By 1130 both the herring gull roost and the kittiwake roost on the low rocks had reassembled to some extent, and at 1140h the kittiwake roost again took off for no obvious reason, but not the herring gulls. At 1202h the kittiwakes again panicked for no obvious reason, and again at 1215h.

As the Aztec approached at 1235h the kittiwakes took off from the low slopes to the south but not to the north of the site. As the plane passed over the herring gull roost did not budge nor did the kittiwake roost to the north. At 1238h the aircraft passed right over the stack and the herring gulls roosting on the top of the cliffs paid no attention whatsoever. None of the birds had left from the ledges or from nests but kittiwakes were quite numerous in the air, presumably having come

from some roosts which could not be seen from our vantage point. The kittiwake roost to the north of the stack remained intact, as did the herring gull roost. At 1240h the Aztec came in for the last pass over the area and the kittiwakes sitting on the sea took off but breeding birds on the stack did not respond. The kittiwakes which took off from the sea landed again, on the sea, almost immediately. At 1243h a further Sikorsky S61 passed over at about 150 m and about 1/2 km or so inland. No response by the birds on the stack was detected.

Most kittiwakes had nestlings, some still eggs; guillemots and puffins were carrying fish, and young guillemots were seen on the ledges."

Conclusions

"The passage of a large helicopter and a twin-engined monoplane at a height of 150 m above sea level, and 100 m above the cliff top, caused no detectable effect on the attendance of breeding kittiwakes and guillemots at their nests or ledges, during two sets of observations, one during the egg-laying period and the other at hatching. We were unable to repeat the observations later in the breeding season.

Fulmars, shags, razorbills, puffins and herring gulls seemed equally undisturbed, but data were too few for statistical analysis.

The Buchan cliffs, where these observations were made, are on the normal route of helicopters flying from Aberdeen Airport to rigs and platforms in the North Sea, and it may be that the birds have become accustomed to these aircraft.

Panic flights of kittiwakes and herring gulls gathered at roosts away from the nesting ledges were recorded on several occasions, often with no obvious cause. The response to overflying aircraft was essentially similar in character.

It must be emphasized that these conclusions refer to the species and phases of the breeding season which were covered by the observations and to aircraft flying at not less than 100 m above the cliff top. It may be that similar disturbance at other stages of breeding activities of these species could have undesirable effects, and, of course, other species in quite different habitats, such as terns and ducks, may be much less tolerant of low-flying aircraft.

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Gollop, M. A., J. E. Black, B. E. Felske, and R. A. Davis. 1974. Disturbance studies of breeding Black Brant, Common Eiders, Glaucous Gulls and Arctic Terns at Nunaluk Spit and Phillips Bay, Yukon Territory, July 1972. Arctic Gas Biological Report Series 14(4). 49 pp. Chapter IV, pages 153-201.

Introduction

"Coastal breeding birds tend to concentrate their feeding, nesting and brood-rearing activities in relatively inaccessible parts of beach and deltaic areas. In the natural setting of coastal ecosystems, this gives the birds the advantage of relative security from predators and other forms of disturbance. As a consequence of this concentration, on the other hand, forms of disturbance that overcome this isolation factor tend to expose large numbers of the population to new dangers. This form of concentration increases the danger of even small and localized forms of disturbance. The probability of increased aircraft traffic and human activity along the coastal regions, associated with the various phases of gas pipeline activity, therefore brings an increased threat to the birds concentrated along this area."

"This study of disturbance of breeding black brant (*Branta bernicla*), common eiders (*Somateria mollissima*), glaucous gulls (*Larus hyperboreus*), and arctic terns (*Sterna paradisaea*) concentrates on those phenomena which serve as the most reliable indicators of potential disturbance of the species population. These are reproductive success, behavioral response and population density."

"Objectives of the study were to determine the effects of helicopters and fixed-wing aircraft and human activity on the incubation and reproductive success of the above four colonial species which occupied the islands and spit areas of the Firth River delta and Phillips Bay, Yukon Territory."

Methods

Helicopter Disturbance—Black Brant and Common Eider

"Twenty-five eider and two brant nests were marked with numbered stakes on 27 June; as new nest sites were built, during the study period, stakes were placed accordingly. An observation tower with an 8 foot construction scaffolding base, topped by a 4' x 4' x 4' observation box with one open side, was placed approximately 60 yards north of the eider colony and brant nests."

"Undisturbed nesting and incubation behavior were observed from the blind on 1 July from 1015 to 1615 A.D.S.T. On 2 and 3 July a Jet Ranger, 317 hp helicopter was flown over the colony at varying times and altitudes (Table 2). The reactions of the birds to the helicopter flights were recorded on the previous day. Any flight from the nest or ground was considered to be the effect of disturbance."

Fixed-wing Aircraft

"A Cessna 185 S.T.O.L. light plane was flown over nesting glaucous gulls at Phillips Bay and nesting common eiders, glaucous gulls and arctic terns at Nuneluk Spit at varying time intervals and altitudes (Table 3) on 2, 5, 6, and 8 July."

"One of the two Phillips Bay islands was visited on 4 July and eight nests were recorded. It was not possible to reach the second island and no data were obtained on the exact number of nests there."

"Disturbance of incubating and non-incubating birds was recorded from the aircraft because weather conditions prevented the presence of ground-stationed observers. Any flight from the nest or ground was considered to be the effect of disturbance, since observations prior to the disturbance revealed that under undisturbed conditions flights from the nests were rare."

Human Disturbance

"Observations were recorded during the presence of investigators near nesting black brant, common eiders and glaucous gulls at Nuneluk Spit."

Results

"Black brant. There were two brant nests under observation. On two occasions, brant were observed to leave the nest as a result of helicopter flights over the area. One brant left its nest 2 July when the helicopter passed at a height of 500 feet and one on 3 July at 250 feet. The nesting brant were extremely wary of observers, spending much time away from their nests and thus making it difficult to obtain consistent data on their reactions to the aircraft. The data obtained seem to indicate that this species is particularly sensitive to all forms of disturbance."

"Common eider. No eiders appeared to have been disturbed by the helicopter flights. The data recorded from activation of the microswitches did not provide any interpretable results. It is apparent from these experiments that nesting eiders will not flush from the nest unless subjected to extreme disturbance. There were 34 eider nests under observation."

"On 2 July, non-nesting eiders were disturbed by passing aircraft at the following altitudes: 3000 feet (13 birds); 500 feet (2); 250 feet (1); 125 feet (4). On 2 July, non-breeding brant were disturbed by passing aircraft at the following altitudes: 250 feet (8); 125 feet (4). No record was kept of the numbers of non-nesting eiders or brant in the vicinity of the observation tower at each helicopter pass, so the percentage of such birds affected by each disturbance could not be calculated."

"There was no response shown by any incubating eiders at Nunluk Spit to any of the fixed-wing aircraft flights made over the colony."

"Twenty non-incubating birds flew from the path of a fixed-wing aircraft flying at 250 feet on 8 July at the Nunluk Islands. This is our only observation of this species during this phase of the study."

"Glaucous gull. Helicopter passes at 3000 feet and 2500 feet produced no apparent disturbance to incubating gulls, but some effect was evident at 2000 feet, and this increased steadily at successive intervals until it reached 100% at the 500 foot or 250 foot levels. On 2 July there was a significant negative correlation between height of the helicopter and percent of birds which flushed ($r = -0.751$; $P < 0.05$ for Kendell's rank correlation coefficient for the altitudes from 3000 feet to 500 feet inclusive). On 3 July there was also a significant increase in percent of birds flushing as the altitude decreased ($r = -0.966$; $P < 0.05$ over the altitude range of 2000 feet to 250 feet inclusive). Some form of conditioning may take place if birds are exposed to additional disturbance within a short time."

"There is some indication that birds which have been previously disturbed may be more prone to redisturbance since more birds flew up at higher aircraft passes on the second day. However, more data are necessary before this can be definitely ascertained. It would be difficult to determine a critical level of disturbance if conditions are variable or if the effects of repeated disturbance are cumulative."

"A relationship between the level flown by the helicopter on the second day of the study and the time which the birds remained off the nest was noted. It can be seen that the length of time during which the nest is vacated increased as the flight passes decreased in altitude."

"Helicopter flights had no apparent effect on the reproductive success of the breeding gulls. Mean clutch size of forty-one nests in the study area was 2.51 eggs which was similar to previously observed clutch sizes (MacPherson 1961). Hatching results (Tables 7 and 8) indicate no adverse effects of disturbance if those nests which were discovered empty are considered to be successful. No abandoned clutches or young were discovered."

"Non-incubating gulls showed less tolerance to disturbance than did those with nests. It was impossible to keep an accurate count of the non-breeding birds present in the vicinity of the site, but general notes taken in the field do provide an indication of greater intolerance. On 2 July, ground observations of gulls without nests revealed that the earliest signs of disturbance occurred at 1500 feet compared to 1000 feet for incubating birds. At 750 feet and all lower altitudes, all non-incubating birds were disturbed. The critical height for 100% disturbance of incubating birds was 500 feet. Exactly the same critical height was determined on 3 July, though on this date the height at which the birds were first disturbed was not recorded."

"An observer in the helicopter on 2 July noted disturbance reactions at 2500 feet (1 bird) and 2000 feet (14 birds). His estimate of the total population of gulls on the two islands was 125 birds. Table 10 summarizes the response of non-incubating gulls to helicopter disturbance."

"There were 39 known nests on the two Nunakuk Spit Islands and 8 known nests with an additional 17 suspected nest sites on the two Phillips Bay Islands during the time of this study."

"Incubating birds showed almost no response to flights over them at 1000, 500, 250, and 125 feet. The only exceptions were two birds which walked off their nests on 8 July at Phillips Bay during a pass at 250 feet."

"Flights with fixed-wing aircraft above 250 feet did not disturb non-incubating gulls and even at 125 feet numbers of birds disturbed varied greatly (Table 11) with each pass."

"Tentatively, a critical level of disturbance appears to be reached at a height of approximately 250 feet."

"Arctic tern. Under undisturbed circumstances on 1 July, only four of nine clutches were being incubated. Incubating females spent a total of less than ten minutes on the nest over the six-hour observation period."

"Only one bird was incubating on 2 and 3 July when helicopter disturbance was initiated. This female showed no sign of having been disturbed by flights above 1500 feet. At all levels from 1000 to 20 feet, the bird flew from the nest and returned within one minute after the helicopter had passed."

"Mean clutch size of eleven nests found on the island was 1.3 eggs, which compares with a clutch of 1 - 2 eggs as found by other investigators (Bickerton 1909; Macoun and Macoun 1909; Pettingill 1939; Ecklund 1944; Williams 1947; Hawksley 1957). Only two of these nests hatched during the study period, producing a total of 3 chicks (Table 9). Nine of the nests appeared to have been abandoned since the eggs were cold and few adults were present near the nesting area."

"It may be that the arctic tern is an unusually sensitive species and that it was the cumulative effect of a number of instances of sporadic disturbance prior to the study which caused this large-scale abandonment."

"Approximately 50 non-incubating terns were present in the area of observation. They responded in a fashion similar to that of the incubating birds. All birds flew from the ground during overflights at 1000 feet and at all levels below that. In more cases the birds returned to the ground in less than one minute although occasionally they remained out over the water to feed."

"Nothing can be said about the effect of fixed-wing disturbance on incubating terns as there were too few nests and their locations proved to be too difficult to pinpoint from the air."

Summary

2. "Aircraft disturbance affected the normal incubating behavior of black brant, glaucous gulls and arctic terns but had little obvious effect on the incubation of common eiders. However, the effects of aircraft-induced stress on the delicate energy balance of incubating eiders is unknown."
3. "Helicopters were more disturbing to birds than were fixed-wing aircraft."
4. "Non-incubating birds showed greater intolerance to disturbance than did incubating birds."
5. "Indications are that disturbance as a whole may be detrimental to the nesting success of black brant and arctic terns."

Gollop, M. A., R. A. Davis, J. P. Prevett, and B. E. Felske. 1974.
Disturbance studies of terrestrial breeding bird populations: Firth
River, Yukon Territory, June 1972. Arctic Gas Biological Report
Series 14(3). 56 pp. Chapter III, pages 97-152.

Introduction

"The objective of this study was to determine the possible impact of the exploration, construction and operational phases of a proposed gas pipeline on the population densities and reproductive rates of bird species within the zones of activity on the Yukon North Slope."

"Specifically, the study described herein was designed to determine the potential impact of camps established by exploration and construction crews engaged in pipeline activity. Since aircraft, both fixed-wing and helicopter, are an integral part of activity in the North, aircraft disturbance was included as part of the study. Results should indicate whether day-to-day activities of men in the field and their support systems would affect the population size and reproductive success of birds breeding in the vicinity of the camp."

"The study area was situated at MacNeish Lake, near the Firth River, on the coastal plain of the North Slope, Yukon Territory. The coastal plain is an area of low, sloping relief bounded on the north by the Beaufort Sea and twenty-five miles to the south by the British Mountain component of the Arctic Plateau."

"Lakes are common features of the lower reaches of the coastal plain. Remnants of the glacial history, these lakes are probably the result of melting ice as some occupy abandoned channels of major streams where flows have ceased or shifted elsewhere."

"The control and aircraft disturbance areas were both located along ridge lines and contained mainly heath-tussock tundra. The human disturbance plots were located in a low-lying polygonal area and were largely sedge-marsh. A detailed description of these habitat types is presented (Schweinsburg 1974) in Volume X of the Canadian Arctic Gas Study Limited Biological Report Series."

"Lapland longspur (*Calcarius lapponicus*). This small perching bird is circumpolar in distribution, and it may be the single most abundant and widespread bird in the terrestrial Arctic. Within its range, this longspur occupies almost all open tundra areas in greater or lesser densities, depending upon the availability of nesting habitat. However, it tends to avoid extremely wet meadows and the very xeric lichen-covered areas where tussocks are not available (Williamson 1968)."

Types of Disturbance--Camp

"Northern Engineering Services Firth River camp was established 24 May 1972. Camp activities included: (1) 2.5 hp diesel generator in continuous operation; (2) six residential tents, two kitchen tents and a supply tent with crews of from six to twenty men; (3) one or two Jet Ranger helicopters which averaged a total of six arrivals and departures per day at the camp, resulting in a total of 110 hours of operation out of the camp during June; (4) 3 June 1972: The area to the east of the camp experienced eight hours of continuous helicopter operation during relocation of the camp; (5) walking in the area mainly involved ornithological personnel; (6) all garbage was burned in an incinerator or removed to Inuvik. There was little attraction for ravens, gulls, or other avian scavengers; (7) a Samoyed husky was present in the camp for the duration of the study. The dog ranged the surrounding tundra on most days."

Aircraft Disturbance

"A Jet Ranger helicopter was flown at an altitude of approximately fifty feet over the aircraft disturbance plots in a circular fashion. Three circles of the plots were made during each treatment. Flights were made on an average of twice a day during the month of June unless prevented by weather."

Results

"Data indicate through a Kruskal-Wallis Test that there was no significant difference among nesting populations on the control, aircraft disturbance and human disturbance areas ($P > 0.1$). There was, however, a trend toward lower populations on the disturbed areas."

"Population densities for the three experimental areas are presented. Density figures for different plots in the Firth River area varied between 347 birds/mi² and 594 birds/mi² with a mean density of 418 birds/mi². On the undisturbed area, density figures varied between 398 birds/mi² and 594 birds/mi² with a mean density of 479 birds/mi². The variation in this area appears to be the result of topography: areas with standing water and lack of tussock vegetation were very sparsely populated by longspurs."

"No significant difference was noted between clutch sizes at nests found on the three study areas ($\chi^2 = 1.24$; $df = 2$; $P > 0.5$). Thus, there is no evidence that human presence and activity, and aircraft traffic affect the clutch size of Lapland longspurs."

"Fledgling success on the control plot was 55.9%; on the aircraft disturbance plot 34.5%; on the human disturbance plot 40.0%. Fledgling success (percent of young which fledged) was higher on the control plots (55.9%) than on the combined disturbance plots (37.1%). These differences cannot be

analyzed directly since the independent unit for analysis (in a statistical sense) is the brood rather than the individual nestling. The results must be analyzed on a per brood basis."

"To summarize this section, it can be said that the storm caused equally high mortality on late hatching broods regardless of the amount of disturbance. However, the early-hatched broods on the combined disturbance study plots were less able to survive the storm than were the broods of the same age on the control plots. The reasons for this are unknown, but it is possible that nestlings on the disturbed plots were in poorer condition prior to the storm than were those on the control plot."

Other Birds

"American golden plover. Three nests located on the aircraft disturbance plots were closely and deliberately harassed during one of the treatment periods. Only one nest gave satisfactory results since the other two were disturbed by the observers moving into position. The female on this nest did not respond to the pass at 100 feet and then flew from the nest during the 50 foot pass when the helicopter was directly overhead. The bird alighted approximately 60 feet from the nest and did not respond to the next pass at 25 feet. The bird returned to her nest after observers left the immediate area. This harassment did not affect the success of the nest."

"Willow ptarmigan. Census data from all test plots were combined due to the lack of apparent effect by aircraft and camp activity. The combined figures yielded a density of 33 males/mi². Density of total breeding birds is more difficult to calculate due to the possibility of polygyny in ptarmigan. It is therefore suggested that a minimum density based on the assumption that each male has at least one mate would yield a breeding population figure of 66 birds/mi². This compares with an estimate of 26.8 birds/mi² derived from 1971 transect data (Schweinsburg 1974), but these results probably reflect the relative inconspicuousness of female ptarmigan and are doubtless closer to the actual density of males than of pairs."

"Both willow and rock ptarmigan flew in response to low-flying helicopters. Camp activity appeared to have no effect on territorial male willow ptarmigan."

Discussion

"It was found that camp activity, including aircraft, personnel and other mechanical activity, had no significant effect on the population density of Lapland longspurs. This appears to agree with a brief reference to longspurs in the vicinity of the Royal Canadian Air Force base at Frobisher Bay, Baffin Island, by Sutton and Parmelee (1955). Both their observations and the results of this study support the suggestion that many passerine birds are habitat-specific and will, in terms of sheer population density,

tolerate a degree of disturbance so long as the natural vegetation remains intact. It should be pointed out, however, that there was a statistically insignificant trend towards a smaller population density on the disturbed areas. Were this trend to prove cumulative from year to year, the effect could soon become significant."

"The unusual weather conditions which occurred during critical periods of the study make it difficult to precisely evaluate the impact of disturbance on the reproductive success of nesting longspurs. It would appear from the data, however, that undisturbed plots were more productive than disturbed plots."

"However, the establishment of territories on all of the plots was simultaneous, possibly indicating that habitat conditions suitable for the commencement of the breeding cycle were also simultaneously available. This would suggest that the aircraft and human disturbance may have delayed the onset of nesting."

"Under normal conditions, areas first selected by arriving birds are usually the ones optimal for reproductive purposes. If disturbance should influence this selective process, several detrimental effects could result. Disturbance might delay the commencement of breeding activity on areas of optimum habitat, thus reducing the productivity of these areas. In addition, it may lead to early establishment on suboptimum habitat, thus also affecting reproductive success."

"There are a number of critical points in the breeding chronology of any species, and even relatively mild disturbance at such times could strongly influence the success of the breeding cycle."

Summary

1. "No statistically significant difference in population density was noted in Lapland longspurs on control, human and aircraft disturbance sites."
2. "Statistically significant differences were noted in the reproductive success of Lapland longspurs on control, human and aircraft disturbance sites. These included a number of addled eggs, nest abandonment, hatching success, premature disappearance of nestlings, and fledging success. Fledgling production per pair and population turnover rates also appeared to be affected."
8. "Within the short-term limits of this study, none of these other species (*i.e.* golden plover, willow ptarmigan, rock ptarmigan) appeared to be affected by the disturbance."

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Gollop, M. A., J. R. Goldsberry, and R. A. Davis. 1974. Effects of gas compressor noise simulator disturbance to terrestrial breeding birds. Babbage River, Yukon Territory, June 1972. Arctic Gas Biological Report Services 14(2), Chapter II, pages 49-96.

Introduction

"Plans for the proposed pipeline across the North Slope of the Yukon Territory call for the establishment of gas compressor stations at regular (approximately 50 mile) intervals along the route. Considerable noise is created by the machinery and passage of gas at these stations. Bartonek (1969a) referred to the possibility that pumping stations in the Atigun River Valley, Alaska, would disrupt Dall sheep populations there, but the impact, if any, of these stations on bird populations has not been studied. For that reason, this study was implemented to discover how compressor station noise would affect population densities and reproductive success of breeding birds on the tundra."

"The study site was located along the Babbage River, approximately 12 miles southeast of Phillips Bay, Yukon Territory (N.T.S. map-117D; 1:250,000; Herschel Island) and directly along the coastal route of the proposed pipeline."

"Topography in the general area is typically rolling tussock tundra containing flat polygonal areas and cut by braided meandering streams."

Methods

"Since it was not possible to conduct studies at an actual compressor station, it was necessary to simulate the sounds that would be produced by such a station. J-Mar Electronics Limited of Toronto designed and built the sound simulators used in this study."

"Two simulators were run simultaneously during the study. Each unit had loud-speakers which simulated the exhaust, scrubber, air intake and bypass loop at the same sound levels as those found in a gas compressor. The electronics consisted of a white noise generator, active filters to synthesize the separate sounds, amplifiers and loud-speakers. Power was supplied by a Kohler generator mounted on the simulator platform."

"The simulators were brought into the study area on 20 and 21 May. They were tested on 21 and 22 May but were not left running since it was not yet possible to station observers at the site."

"On 28 May, the simulator was turned on and left running continuously through the study period until 7 June. Shutdowns were kept to normal maintenance or minor repair and at all times at least one simulator was in operation."

"The Lapland longspur (*Calcarius lapponicus*) was the only species whose population density was sufficient to allow systematic study within a small

area such as that encompassed by the plot system employed. Data on populations and nesting of other species have been used in drawing general conclusions about their reactions to disturbance."

"The longspur population in the general area, based on figures from the undisturbed area (2.60 acres per territory), would be 492 birds per square mile; based on figures from the disturbed area (2.68 acres per territory), the population would be 478 birds per square mile. Averaged together, the two study areas yielded an overall population figure of 485 birds per square mile."

Discussion

"The sound emitted by the gas compressor noise simulators had no measurable short-term effect on Lapland longspurs breeding in their vicinity. Sample sizes of other species were too small to base conclusions on. The study could not be initiated until shortly after the majority of the resident species had arrived, so it is not known what effect the presence of a compressor station operating at the time when the birds first arrive would have on territory selection. The long-term effect of a permanent installation and its support activities on the more sensitive species has also not been tested. Care should be taken in selecting locations for the compressor stations. It would be best if the stations could be kept away from waterfowl areas, as these birds are likely to be far more sensitive to disturbance of this type."

Summary

1. "No statistically significant difference in population density was noted in Lapland longspurs on the control and disturbance sites."
2. "No overall measurable differences were noted in the reproductive success of Lapland longspurs on the control and disturbance sites."
6. "The long term effects of disturbance are unknown."

Literature Cited

- Bartonek, J. C. 1969a. Arctic Slope and Trans-Alaska Pipeline Task Force report: the bird resources of Alaska's Arctic Slope and petroleum development. Mimeo. report: on file at Northern Prairie Wildl. Resource Center, Jamestown, North Dakota. 33 pp.

Gollop, M. A., J. B. Goldsberry, and R. A. Davis. 1974. Aircraft disturbance to moulting sea ducks. Herschel Island, Yukon Territory, August 1972. Arctic Gas Biological Series 14(5). Chapter 5, pages 202-231.

Methods

"Aircraft disturbance was begun on 6 August and observations as outlined were made $\frac{1}{2}$ hour before and $\frac{1}{2}$ hour after each flight. Flights were made at hourly intervals beginning two hours after the observers were positioned on the island and ending one hour before the observers were picked up. A total of eight hours was spent observing on this day. The helicopter flew a predetermined path over the sea ducks approximately 100 yards from shore at altitudes of 750 feet, 500 feet, 400 feet, 300 feet, 200 feet, and 100 feet."

"On the second day of disturbance, 14 August, observations were concentrated on a smaller area and consisted of hourly flights at 100 foot altitudes, 100, 200, 300, and 400 yards from shore."

Results

"Finally, all observers noted that birds became aware of the aircraft long before it could be seen by the birds or the observers. This reaction in some instances was noted as a general awareness, with birds looking toward the direction of the aircraft, a general restlessness and in some instances, a movement away from shore. These reactions were noted while the aircraft was one-half to one mile away. Since the physiography of Herschel Island in many instances did not allow the birds to see the aircraft, these reactions must have been in response to the sound of the aircraft."

Discussion

"Helicopter disturbance (Bell 206B) apparently did not affect the populations of molting sea ducks at Herschel Island. That is, no detectable numbers were driven away from the area. However, since the birds were flightless they could not travel far. Continued harassment over a period of several days might have caused the birds to reach a threshold level of tolerance which would not be obvious with 2 separated days of disturbance, but it was not possible to test this possibility within the framework of the present experiment."

Summary

1. "Population levels of molting sea ducks did not appear to be affected by disturbance."
2. "Ducks were driven from land by the aircraft."

3. "Oldsquaws rested and slept (on water) more on disturbance days; surf scoters rested less."
4. "Swimming and feeding activities of oldsquaws appeared to be unaffected by disturbance. Surf scoters swam and fed more, probably because their normal sleeping and resting habits had been disrupted."
5. "Flock sizes and number of birds in flocks (as a percentage of the total birds) increased as disturbance continued."
6. "The first responses to the helicopter were shown at 750 feet when birds began moving off land and out from shore."
7. "Surf scoters appeared to be more sensitive than oldsquaws to the disturbances."

Grubb, M. 1978. Effects of increased noise level on nesting herons and egrets. Proc. Colonial Waterbird Group. Pp. 49-54.

Introduction:

There is currently little information available concerning effects of increased noise levels on nesting wading birds, and even less is known about decibel levels which these birds will tolerate. The purpose of this study was to: 1) document existing maximum noise levels caused by outside sources in a large, mixed species heron rookery, 2) predict future maximum noise levels from increased air traffic and 3) observe the birds' reaction to aircraft overflight approximating the calculated future maximum noise levels.

These studies were conducted as part of an Environmental Impact Assessment Report prepared for the proposed expansion of the St. Paul Downtown Airport, St. Paul, Minnesota and were funded by the Minneapolis-St. Paul Metropolitan Airports Commission.

Methods:

The first step in the noise analysis was a field survey to document existing noise levels in the heron rookery. This was accomplished through the monitoring of noise levels for 20 minutes each at three different locations within the rookery. A calibrated tape recorder was used and data analyzed as described by Hoyle, Tanner *et al.* (1978). Aircraft noise levels experienced by the birds due to the test overflight (described below), and future noise levels in the rookery should the proposed runway be built, were calculated using published data for noise emission and performance of different aircraft type.

Calculated noise levels are expressed in both dBA's and dBC's. Use of the dBA scale de-emphasizes the low frequencies and closely simulates the frequency response of the human hearing system while the dBC scale measures all frequencies in the human audible range. Since birds may be able to hear aircraft at frequencies below 20 Hz which people do not hear, the dBC scale is also presented.

The series of overflights was conducted in early May 1978. A single engine Cessna 172 aircraft made six flyovers at the following elevations above the ground: 800 feet, 600 feet, 400 feet, 300 feet, 200 feet and 150 feet. The plan was flown on a simulated approach pattern to the proposed runway, placing it directly over the rookery. The plane flew at 85 knots and at 1800 revolutions per minute during the first overflight at 800 feet; the overflights at 600, 400, 300 and 200 feet were conducted at 105 knots and 2400 revolutions per minute while the last overflight at 150 feet was conducted at 100 knots and 2400 revolutions per minute. The last five overflights were conducted using take-off power; the objective of this was to expose the rookery to maximum noise levels possible from this aircraft.

The pilot and two observers were present in the plane; two observers were stationed on the river bank across from the rookery.

In this case under study, the results of the overflight indicated the nesting herons may not be disturbed by the presence of aircraft over the rookery or by the increased noise levels.

The only previous known study concerning effects of aircrafts on nesting birds occurred in Scotland. A large helicopter and a twin engine monoplane was flown at a height of 300 feet above seabird nesting areas. There was no evidence that the passage of the aircraft interfered with incubating or brooding birds (Dunnett, 1977).

This lack of response from the Pig's Eye rookery may be due in part to habituations, a process where animals become adjusted by repetition of new sounds. As discussed above, the herons are currently exposed to noise from barge, automobile, and aircraft traffic, as well as industrial noises. Habituation to jet aircraft noise is reported for feeding starlings by Boudreau (1968) and for feeding pheasants by Blockpoel (1976). Considering wading birds, nesting Great Blue Herons became accustomed to outboard motor noise in Floridays waterways, while feeding Great Blue Herons were eventually not disturbed by speeding trains. Green Herons were also reported to become habituated to nearby fire engine sirens (Meyeriecks, 1960).

Conclusions:

It is difficult to draw any hard conclusions from this study as data available in the literature and data collected in this study were limited. It would appear that because Pig's Eye Rookery is located in an already industrialized area that the herons and egret are habituated to high noise levels and that an increase in this noise level may not be detrimental.

Summary:

It is known herons often breed in secluded locations and may abandon nesting efforts if disturbed. However, little information exists in the literature concerning the general subject of effects of increased noise levels on nesting herons and little is known on decibel levels which nesting herons will tolerate. This paper reviews the existing literature and presents the results of a field study conducted to address the above problem.

Existing noise levels were measured in a large mixed species heron rookery in St. Paul, Minnesota. A small plane then flew over the rookery at elevations ranging from 150' to 800' above the ground. Calculated maximum noise levels from this plane were 9 dBA greater than calculated existing maximum noise levels from aircraft and 20 dBA greater than measured existing maximum noise levels. There was no response from the nesting birds to either the increased noise levels or the presence of the aircraft. The fact that these birds are currently residing in an urbanized environment may have resulted in their habituation to noise disturbances.

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Authors' Abstract

"The objectives of this study were to determine (1) the density indices of populations of breeding birds on the disturbance and control plots established in 1972 in the areas of the Babbage and Firth rivers, Yukon Territory, and (2) whether the disturbance experiments conducted in 1972 affected the densities of populations of breeding birds present in 1973 on the disturbance plots.

Sound simulator, helicopter and human disturbance plots, and control plots in the Babbage and Firth river areas that were surveyed through use of the plot census method in 1972 were re-surveyed through use of the transect survey method in 1973.

Only the Lapland longspur was observed during both years in numbers sufficient for systematic comparisons.

On the basis of the available data, this study concluded the following:

- (1) that the simulator sound disturbance experiments conducted in 1972 at the Babbage River disturbance plot did not affect the density of Lapland longspurs present on this plot in 1973;
- (2) that the effects upon populations of Lapland longspurs of the aircraft and human disturbance experiments conducted in 1972 at the Firth River disturbance plots extended to 1973;
- (3) that the increases in the 1973 density indices were partially due to the earlier, milder spring of 1973;
- (4) that the differences in methodology between the 1972 plot censuses and the 1973 transect surveys caused differences in the results that did not reflect actual differences in densities, but that in the case of the Lapland longspurs these differences could be adjusted through application of the 1.00:1.83 ratio derived from a comparative study of census techniques that was conducted in 1973 and at a site approximately 18 km south of the Babbage River simulator disturbance plot;
- (5) that the increases in the 1973 density indices of Lapland longspurs could have been partially due to the later scheduling of the 1973 surveys;
- (6) that clarification of the long-term effects of the disturbance experiments and of the relative importance of variations in weather conditions, methodologies, and scheduling should result from additional censuses of the Babbage River and Firth River plots in 1974."

Herter, D. R. 1980 (Not for Publication). Habitat use and harassment of sandhill cranes staging on the eastern Copper River, Delta, Alaska. Unpublished Report. Alaska Co-operative Wildlife Research Unit Semi-Annual Progress Report. Vol 32(2):16-19. July 1, 1980-December 31, 1980.

Partial Abstract

Page 17-18

Sandhill cranes are particularly shy and wary birds and disturbance by humans can restrict crane usage of certain areas (Walkinshaw, 1949). Overflights of feeding and migrating crane flocks were conducted with light fixed-wing aircraft on the ECRD in fall 1980 to assess disturbance effects on the birds. An airborne observer directed flights over cranes and recorded reactions on a portable tape recorder while a ground observer stationed in the observation tower recorded crane movements after disturbance. Crane reactions appeared to vary depending on weather conditions but passes under 200 ft. usually forced cranes to take flight while the aircraft was still $\frac{1}{4}$ mile from the birds. In general, the louder the plane's engine the greater the reaction, but cranes were never so disturbed as to leave the ECRD and rarely were they displaced from the wet meadow habitat. Helicopters crossing the study area created much more notable disturbance as crane flocks fully 1 mile from the aircraft took flight or altered flight directions but again long term effects were usually absent.

Walkinshaw, L. H. 1949. The sandhill cranes. Cranbrook Inst. Sci. Bull. 29. Bloomfield Hills, MI. 202 pp.

Herter, D.R. 1981. (Unpublished) Habitat use and harassment of Sandhill cranes staging on the eastern Copper River Delta, Alaska. Alaska Cooperative Wildlife Research Unit, Semi Annual Report, 33(1):12-14.

General. P. 14. (Not to be cited without permission)

"Disturbance data were also collected and analysis is continuing. Regression analysis indicated that flock size and time spent at the site before disturbances was not correlated to reaction severity. Intensity of disturbance based on distance cranes flew after disturbed, distance of the disturbance source to the flock before they flushed, and time spent in the air after disturbance were analyzed for seven disturbance sources: (1) non-pursuing bald eagles (Haliaeetus leucocephalus), (2) pursuing eagles, (3) people, (4) people hidden by cover, (5) airplanes, (6) helicopters, and (7) hunters. Helicopters and hunters produced the strongest reactions from cranes, and airplanes were intermediate. People and eagles tended to produce less severe reactions, although crane flocks pursued by eagles remained in the air and flew farther than when disturbed by people or non-pursuing eagles. Disturbance levels from hunters and eagles are already fairly high and any added disturbance, especially from aircraft, could be detrimental to staging cranes."

Horejs, B. L. 1981. Behavioral response of Barren Ground Caribou to moving vehicle. *Arctic* 34(2):180-185.

Author's Abstract

ABSTRACT. Behavioral responses of individual Barren Ground caribou (Rangifer tarandus granti) to a 3/4-ton pickup truck were quantified on 36 occasions. During 34 of those observations the vehicle initially approached at a speed of over 56 km/h. Forty-eight percent of the individual caribou reacted to the vehicle by running away while 38% trotted away. The mean flight duration of females was 73 ± 11 sec, that of males 38 ± 6 sec. ($p=0.09$). Caribou encountering a moving vehicle exhibited signs of excitement and fright, including the excitation jump and tail-up response. Reversal of direction and/or splitting of the group involved 29% of the individual caribou. The type of habitat (forested vs. open) did not have an effect on observation duration ($p>0.50$) or on the mean distance at which caribou were first encountered ($p>0.50$). The distance from the vehicle at which animals began to flee did not differ between sexes ($p>0.50$) or habitats ($p>0.50$) but was as great for both sexes as that reported for females with young calves. In forested habitat male caribou allowed a much closer approach than females ($p=0.08$) but closeness of approach did not differ between the sexes in open habitat ($p>0.50$).

Author's Conclusions

In general, caribou exhibit signs of anxiety and fear when encountering a fast-moving vehicle, and they exert themselves strenuously for a short period when withdrawing from a vehicle. It appears that caribou react to a vehicle based on the rate of approach, involving the principle of looming, rather than on the movement itself; in most instances, caribou flee for a relatively short period of time, that period very likely ending when the animal feels it has reduced the threat to near zero.

One of the tenets of behavior in response to harassment is that animals avoid the area(s) in which they experience disturbance (Geist, 1971). Reindeer did exactly this in Finland when herders began using snowmachines (Pelto, 1973). Cameron et al. (1979) also present data to support an avoidance response by female caribou and their calves in relation to the Trans-Alaska Pipeline. I suggest that caribou might begin to avoid the Dempster Highway Corridor if traffic increases in frequency and remains unregulated.

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Reproductive ecology, foods and foraging area of seabirds nesting
on the Pribilof Islands, 1975-1979. Final Report Contract No.
03-5-002-72 Research Unit No. 83. Dept. of Ecol. and Eval. Biology
Univ. of Calif., Irvine.

Summary

Implications for management, pp.224, 226.

"The size and diversity of the Pribilof seabird colonies, as well as their unique population of Red-legged Kittiwakes compels their protection. However, if protection is to be effective, three concerns must be addressed: 1) minimizing adult mortality away from the colony; 2) ensuring food resources remain adequate to sustain not only the adult population, but also reproductive efforts; and 3) minimizing disturbance of breeding birds at their colonies."

"Finally, efforts should be made to minimize disturbance at the colonies, from human activities on or below the cliffs, aircraft and introduced predators. Chronic disturbance is likely to have long-term effects on productivity and possible deleterious and irreversible effects on the colonies themselves. According to our observations, aircraft flying over the colonies have an acute impact on productivity (Hunt *et al.*, 1978). If nesting seabirds can habituate to chronic aircraft disturbance, then long-term effects may be negligible. However, reproductive failure over a period of years may cause seabirds to desert their colonies. Given the uncertainty of the long-term effects of disturbance, care should be taken to reduce this potential impact."

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Reproductive ecology, foods and foraging areas of seabirds
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NOAA/Environ. Res. Lab., Boulder, Colo. 1:570-775.

Johnson, S. R. 1981. Marine Birds in the Alaskan Beaufort Sea: An overview. Pages 58-59 in Acoustical Society of America, San Diego Workshop on the interaction between man-made noise and vibration and arctic marine wildlife.

Author's Abstract

"The Alaskan Beaufort Sea coast stretches about 741 km from Point Barrow to the U.S.-Canada border. Each spring, from late April through June, very large numbers of seabirds or water-associated birds move into the Beaufort Sea, either along the coast or along open water lead systems farther offshore. We have only crude estimates of the total number of water birds entering the Beaufort Sea during this period, but an upper limit is probably about 8 to 10 million--about 2.5 to 3 million sea ducks, primarily eiders and oldsquaw; another 1 million ducks, geese, and swans, of which a large portion are snow geese; and 3 to 6 million shorebirds or wading birds, various gulls, terns, loons, and a variety of other pelagic and coastal species. Early in the season most of these birds are migrants moving to nesting areas in Arctic Alaska or Canada. Many actually nest on the coastal islands or along the coastal fringe of the Beaufort Sea. A large number also nest on the Arctic coastal plain and then move to the coast after the breeding season. The highest densities of marine birds along the Beaufort coast occur in these lagoons which are essentially estuaries having relatively warm water with high densities of food organisms. Barrier islands provide protection from wind, ice and cold water of the offshore marine system.

"There are three major concerns in the current Beaufort Lease area and within immediately adjacent areas:

"(1) Snow Geese on Howe Island, in the delta of the Sagavanirktok River. This small colony of 50-100 nesting pairs is all that remains in the United States. Large colonies exist on Wrangel Island, off the northwest coast of Siberia, and in the Canadian-Beaufort Sea, about 741 km to the east of Howe Island."

"Experiments on the North Slope have shown that snow geese on the ground are extremely sensitive to the noise or sight of aircraft, or possibly some combination of both. This is true when aircraft are at altitudes below approximately 3000 m, and especially below 500 m. Such disturbances have been blamed as the cause of the abandonment by breeding snow geese of the Howe Island nesting colony during spring, 1977."

"(2) Sea ducks, primarily oldsquaw, that molt in the barrier island lagoon systems in or very near the lease area. When molting, they lose their ability to fly. During 1977, it was estimated that a single lagoon, immediately adjacent to the lease area, contained over 50,000 flightless oldsquaws during the peak of the molt. After the molt period, the number of oldsquaw in that same lagoon increased to an estimated 100,000 birds. Experiments and experience in the lagoons showed that molting sea ducks are measurably affected by certain kinds of disturbance, the most significant being low-flying aircraft."

"(3) Gravel barrier islands, Cross Island in particular, supporting species such as the common eider that seldom nest elsewhere. Cross Island supports the largest common eider colony along the Alaskan Beaufort Sea coast—approximately 100 breeding pairs within the lease area. Disturbance associated with either the noise or sight of aircraft is suspected to have caused nesting failure of eiders of Cross Island during the summer of 1977."

Johnson, S. R., W. E. Renaud, W. J. Richardson, R. A. Davis, C. Holdsworth and P. D. Hollingdale. 1976. Aerial surveys of birds in Eastern Lancaster Sound. 1976. Unpubl. Rep. by LGL Ltd., Toronto, Ont. for Norlands Petroleum Ltd., Calgary, Alberta. 15 December 1976. 365 pp.

Correction for Test Differences Pages 319-320

... "The major reason for differences in detectability from front and rear seats include the following:

1. Some species tend to flush far ahead of the survey aircraft (e.g. eiders). Because the front-seat observer can look ahead as well as laterally, he may see these birds and record them on-transect. However, they are likely to be off-transect by the time they come into the visual field of a rear observer, and will therefore either remain undetected or be excluded from his on-transect count and density calculations.
2. Some species tend to dive as the aircraft approaches (e.g. alcids, moulting sea ducks). These species commonly remain underwater for one minute or more. The ground speed of the survey aircraft averaged about 2.7 km per minute. Thus individuals that were detected ahead of the aircraft by the front observer and then dived would likely remain underwater until the aircraft was so far beyond the birds that a rear observer could not see them."

Kushlan J. A. 1979. Effects of helicopter censuses on wading bird colonies. *J. Wildl. Manage.* 43:756-760.

Introduction

Managing and preserving colonially nesting wading birds (Ciconiiformes) requires that the status of colonies be monitored. Monitoring programs, especially when long-term, help to assess population fluctuations associated with environmental changes or management actions (Custer and Osborn 1977, Kushlan and White 1977). Monitoring involves 2 activities; surveys to determine location and general status of bird colonies, and censuses to identify species composition and numbers of birds in the colonies. The most accurate censuses are done on the ground by counting all active nests, counting birds flying over the colony, or by using standard sampling techniques. However, ground techniques are usually uneconomical for large-scale programs and are usually somewhat disruptive because they generally require entering the colony. Aircraft are often used for censusing bird colonies, although with few exceptions (Kadlec and Drury 1968, Dunnet 1977) their potential impact, accuracy, and costs have not been assessed. Use of fixed-wing aircraft seems to provide rather poor data for many species, particularly for colonies where birds nest within the tree canopy. Helicopters allow more accuracy because of their slow speed and the excellent visibility from them. Buckley and Buckley (1976) noted, however, that helicopters are believed by some to cause substantial disturbances to nesting birds. The objectives of this study were to assess disruptive effects of helicopter censuses on wading bird colonies and to evaluate the accuracy and economics of helicopter use.

Methods

The fixed-wing aircraft was a "Lake" single engine amphibian, and the helicopter was a "Bell 47G-2." Ground observers positioned themselves near the colony before the 1st plane arrived.

During the time the aircraft was circling and for 5 minutes thereafter, the ground observers each watched 3 to 6 nests and recorded the behavior of adult birds that were incubating or were at nests with nestlings. I considered that drastic disturbance occurred if a bird left its nest and failed to return within 5 minutes. Lesser reactions of the birds were assigned a value of 1 to 5: exhibited no reaction (1); looked up (2); stood up (3); walked from its nest but returned within 5 minutes (4); and flew from its nest but returned within 5 minutes (5). Comparisons between the fixed-wing aircraft and the helicopter were based on data from 192 observations of great egrets (*Casmerodius albus*), snowy egrets (*Egretta thula*), and Louisiana herons (*Hydranassa tricolor*). Additional observations (N=28) of disturbance were made of double crested cormorants (*Phalacrocorax auritus*) and wood storks (*Mycteria americana*) but these were not extensive enough for the comparative analyses.

Results and Discussion

In all tests, no bird that left its nest failed to return within 5 minutes. Eleven birds that did leave returned to their nests in an average of 1.4 minutes. Thus neither a fixed-wing aircraft nor a helicopter drastically disturbed colonies when flying at altitudes as low

as 60 m. There was no reaction in nearly 3/4 of the 220 observations, and in 90% of the observations a bird either showed no reaction or merely looked up.

The helicopter caused more disturbance of only 1 species in 1 comparison. Results of tests 2 and 3 indicate no increase in the effect of the helicopter when it flew over the colony before the fixed-wing aircraft. Additional qualitative observations of brown pelicans nesting on bushes, cormorants on top of trees, white ibis within the tree canopy, wood storks and great blue herons in trees, and laughing gulls on the ground failed to show any disturbance from helicopters.

Disturbance from helicopter censuses was minor and of short duration. In all but 1 case, disturbance was no greater or less than that caused by fixed-wing aircraft. No predation occurred on the few nests that were abandoned for a short time in response to the aircraft. Some birds flew up and circled around the colony in response to both helicopter and fixed-wing aircraft flights, but ground observations indicated that these were birds without active nests. Several birds that were engaged in pair formation during the census did not fly away. Thus, under the conditions studied, there was no countermanding evidence against use of helicopters near colonies. Although the small impacts shown in this study are probably typical, the effects of aircraft surveys may differ under other conditions or with other aircraft. Tests should therefore be conducted for each use of censusing by helicopter.

Certain procedures can help minimize possible effects of aircraft near colonies. The colony should be approached gradually by first circling it at a distance, either altitudinally or horizontally, and then moving in closer for the count. The aircraft should fly around the periphery of the colony. Helicopters should fly slowly but not hover over the colony. Continual attention should be paid to signs of drastic disturbance during the census. With such precautions and suitable baseline testing, helicopters should prove to be a useful tool for some monitoring efforts.

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Lamothe, P. 1973. Biology of King Eider (Somateria spectabilis) in a fresh water breeding area on Bathurst Island, N.W.T. Unpublished M.A. thesis, Department of Biology, University of Alberta, Edmonton. 125 pp.

Pages 69-70:

"While on a short survey over Bathurst Island on August 27, 1969, a large group of 45 eiders were seen on Bracebridge Inlet. These appeared to be young of the year with molting females, and all birds were incapable of flying. The young birds at that time were estimated to be 35 to 40 days old and seemed almost fully grown. At the passage of the low flying aircraft, no birds responded by diving but attempted flight by flapping along the surface of the sea."

McConnell, W.H. 1980. The Baker Lake Decision on aboriginal rights.
Musk-ox 26:59-77.

Mining Activity and the Caribou P. 60-61
(Aircraft Harassment - Disturbance of Caribou)

"An element in the case of the plaintiffs was that mining activity authorized by the government was disturbing the migratory habitat of the caribou on which their subsistence depended. Injunctive relief or monetary damages depended on evidence of this disruption."

"The court found that prospecting permits covered large blocks of land mainly in the southwesterly and northwesterly quadrants of the Baker Lake area and further smaller blocks north of the hamlet. The work included geological reconnaissance, geochemical sampling, and geophysical surveys requiring the movement of personnel, equipment, and supplies by air, most often by helicopters."

"Mr. Justice Mahoney found that there could be some harassment of migratory caribou herds by exploration activity but not to an appreciably deleterious extent:

Even if one accepts the highly unlikely proposition that a few dozen, even several score, migratory caribou, might be so continuously subjected to a harassment by exploration activity as to be conditioned by it, it confounds reason that a sufficient number could be conditioned so as to affect the collective behaviour of herds numbering in the tens of thousands. The Beverly and Kaminuriak herds are estimated to number 125,000 and 44,000 respectively, with a 35 per cent margin of error either way.

It would only be in those instances where a mining installation "directly and substantially interfered with access to a major water crossing," of which the court found no evidence, that there would be such a change from the accustomed migratory patterns that the hunting rights of the Inuit in the Baker Lake area could be adversely affected."

"As in other areas of the law, the court found that hunting rights could be affected by questions of degree insusceptible to exact measurement. Noisy ongoing activities did not necessarily result in panic among the herds, which passed placidly within a few hundred feet of round-the-clock diamond drilling. High-flying aircraft produced no observable reaction, but aircraft taking off or landing could constitute a serious harassment. Herds did not avoid man-made stationary objects, but showed understandable alarm when approached stealthily or obliquely by humans or vehicles. Harassment occurring in the course of a hunt could be frustrating to Inuit hunters and might, if it caused a panicked flight of terrified animals, result in some fatalities."

"The Inuit claimed that the officially-authorized mining activities had driven two caribou herds to more remote areas where they were inaccessible to those who traditionally relied on them for their livelihood. The defendants, on the other hand, presented expert testimony that the herds were in the process of natural decline, and that at the present rate

the Kaminuriak herd would be extinct within fifteen years. While exploratory activities might result in some caribou deaths, the court found that on a balance of probabilities "activities associated with mineral exploration are not a significant factor in population decline."

Mining Activity and the Caribou P. 68-69

Justice J. Mahoney, Trial Division of the Federal Court of Canada, November, 1979. Court Judgement, Selected Paragraphs.

"The exploration work under prospecting permits is of three kinds: geological reconnaissance, geochemical sampling and geophysical survey. I doubt that any two exploration programs would be identical; however, the evidence satisfies me that the following descriptions are fairly typical today. The movement of personnel, equipment and supplies is by air. The aircraft used are most often helicopters. Geological reconnaissance involves small parties of geologists on the ground. They work within walking distance of their camps. They and their camps are frequently moved by aircraft. Geochemical sampling involves an aircraft setting down on a lake, dropping a dredge and taking samples of the water and bottom sediment. Samples may be taken at half-mile intervals and are removed for analysis elsewhere. A geophysical survey involves an aircraft flying a grid pattern over an area. Initially the lines flown may be a mile or more apart and the altitude four or five hundred feet above the ground but, if the area is interesting the grid may be flown on lines as close as an eighth of a mile apart at as little as one hundred feet. When work is done on the ground, grids are marked with stakes. Depending on the detail of the exploration, those stakes, two to three feet long, are driven into the ground at intervals of from 100 to 500 feet. To aid in spotting them, a few inches of bright, plastic ribbon is usually attached to the top of each. It flutters in any breeze. It rarely survives a winter and is known to have been eaten by caribou. The colour is of no significance to the caribou; they are colour blind."

"The term "harassment" used by the expert witnesses means an outside stimulus producing a reaction in an animal. It is to be qualified by the intensity of the animal's response which may range from no apparent interest to panic. A mild reaction may not be discernible by external observation but can be measured by electrocardiogram. His work in this area led Dr. Geist to disagree with the conclusions drawn by Mr. Miller, on the basis of observation, that caribou did not react to certain things. However, I find no suggestion in Dr. Geist's evidence that such unobservable reactions would have an effect on a caribou that would, in any significant way, influence its behaviour so as to render it more difficult to hunt unless the harassment generating those reactions were applied repeatedly and systematically. What might be achieved in that way by deliberate experimentation would be a highly improbable and coincidental result of the harassments associated with mining exploration activity that may well give rise to unobservable reactions. Even if one accepts the highly unlikely proposition that a few dozen, even several score, migrating caribou might be so continuously subjected to a harassment by exploration activity as to be conditioned by it, it confounds reason that a sufficient number could be conditioned so as to affect the collective behaviour of herds numbering in the tens of thousands. The Beverly and Kaminuriak herds are estimated to number 125,000 and 44,000 respectively, with a 35% margin of error either way."

"The harassments that may arise out of mining activity beyond the exploration stage might well be sufficiently sustained to result in behavioural changes detrimental to the hunt but the evidence simply does not permit a meaningful finding on that point. I say "meaningful" because, while I conclude that the hunt would likely be impaired in the vicinity of a permanent mining installation, I have no basis to determine how extensive that vicinity might be. The evidence as to their observable reactions to base camp activity permits me to infer that there would be no change in general migration routes unless the installation directly and substantially interfered with access to a major water crossing."

"The Kaminuriak and Beverly herds each come into contact with mining exploration activity during its calving and post-calving periods, which occur during June and July. The Inuit witnesses report instances of caribou in both areas being frightened off by low flying aircraft as they were attempting to get a shot at them. A number of camp sites and a good deal of exploration activity have encroached upon major water crossings."

"Ongoing activities, however noisy, do not result in anything like panic. Herds pass within a few hundred feet of round-the-clock diamond drilling for days on end. Similarly, they pass close to occupied camps and through deserted camps. They do not avoid stationary objects. Subject to a particular sensitivity of the females in the calving and post-calving periods and male aggressiveness in rutting season, when approached directly they may merely walk away maintaining a distance of from 20 to 30 feet to several hundred yards. On the other hand, they show alarm when approached obliquely and stealthily. High flying aircraft produce no observable reaction. It seems they are alarmed by abrupt occurrences and by actions they associate with the behaviour of their predators."

"Low flying aircraft are a different matter. I am entirely satisfied that the intermittent passage of low flying aircraft, fixed wing or helicopter, over caribou, such as occurs on take-off and landing and in the process of geophysical survey, constitute a serious harassment of the caribou. While I think it unlikely that any number of individual caribou are subjected to repeated harassment leading to the conditioning projected by Dr. Geist, nevertheless, reaction to the harassment does range through a variety of degrees up to panic and flight and probably does result in the death and injury of individual caribou. Death may ensue if the animal is already in a weakened condition, if it injures itself in flight, if it miscarries or if cow and calf are separated. It is also possible to run such an animal to death. There is no evidence that numerous deaths have occurred but clearly, some are distinctly possible, if not probable, in certain situations particularly during the calving and post-calving periods and at places where the herds are concentrated. It is also clear that should harassment occur in the course of a hunt, the hunter would likely be frustrated. On the other hand, the suggestion of a cumulative, long-term detrimental effect on the caribou herds, by activities to date, is not supported by the evidence."

"The use of fluttering ribbons is a classic method of deflecting animals from their chosen paths. No doubt the beribboned stakes have deflected countless caribou, on countless occasions, from their individual paths. There is no basis in the evidence for concluding that those deflections, however numerous, have involved more than a few hundred feet here and there nor that they have involved the deflection of large numbers of caribou."

Miller, F.L., and A. Gunn, 1979. Responses of Peary caribou and muskoxen to turbo helicopter harassment, Prince of Wales Island, Northwest Territories, 1976-77. Canadian Wildlife Services Occasional Paper number 40, Ottawa, 90pp.

Author's Abstract:

This report provides information on overt behavioural responses of Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) to simulations of three likely categories of helicopter activity that would be associated with construction of a gas pipeline in arctic Canada. The study was carried out on Prince of Wales and Russell islands, Northwest Territories, in summers 1976 and 1977. One three-man team and a Bell 206B turbo-helicopter were used in July and August 1976, and four two-man teams and a Bell 206B were used in June-August 1977. All helicopter harassment overflights were flown at less than 400 m above ground level (m agl): mostly below and above 200 m agl in 1976 and 1977, respectively. The maximum response of an animal during an overflight was taken as a measure of harassment. In total, 3939 individual maximum response samples (IRS) of Peary caribou were obtained during 671 harassment overflights and 4011 IRS of muskoxen during 315 overflights: 64.0% of the Peary caribou samples and 43.6% of the muskox samples responded overtly to the helicopter overflights. It was judged that the 12.1% (477) of the Peary caribou samples and the 21.0% (841) of the muskox samples that were still responding at the extreme level after completion of the overflights represented the animals most seriously affected by the helicopter harassment. Helicopter landings were made on 116 occasions near 736 Peary caribou samples and 69 touchdowns near 1192 muskox samples. In total, 28.7% (211) of the Peary caribou IRS and 12.3% (147) of muskox IRS responded at the extreme level to the harassment. Our results indicated that (a) the responsiveness of cows and calves of both species and solitary bull muskoxen, (b) group size and type, (c) number of calves in a group, (d) the position of the sun and direction of the wind relative to the helicopter, (e) previous activity of the animals and (f) the terrain where the animals were sampled are all factors contributing to the level of response exhibited by harassed animals. There was an inverse relationship between response level and the altitude of the helicopter overflights or the distance away for a helicopter landing and our recommendations were based on that relationship. Evidence for habituation was detected within but not between sets of passes simulating cargo slinging. The levels of harassment did not cause any visible pathological conditions or lead to group splintering or calf desertion. It is not known, however, what the actual short-term costs of harassment to the individuals were in energy, or what are the potential long-term effects to the populations. If we are to advise wisely on the conservation of Peary caribou and muskoxen, there is a vital need for additional baseline data, especially on affinities for and locations of critical areas such as calving grounds, post-calving areas, rutting areas and migratory routes.

Introduction

"The construction and maintenance of a gas pipeline in the High Arctic will lead to great increases in aircraft activity along the route of the pipeline. Polar Gas propose in total the use of 19 aircraft including five light- and two heavy-lift helicopters. The helicopters will be turbine powered and used for such routine operations as pipeline inspections and close-in support of contingency operations."

"As the state of telemetry of physiological parameters such as heartbeat was not advanced enough for use under field conditions, and knowledge of physiology and energetics is limited, especially for muskoxen, we did not measure the cost of harassment in physiological or psychological terms. Instead we noted only observable responses or apparent lack of responses in behavioural terms. Any harassing stimulus causes a change in an animal's environment and the animal will respond in an attempt to adapt to the change. Therefore, the apparent lack of response during some harassments is, in fact, a reflection of our inability to detect a response."

"The literature on harassment of ungulates is scattered among different subjects such as animal husbandry, ethology, range and wildlife management, physiology and psychology. Geist (1975) and Mair (1976) compiled partial general bibliographies of harassment. Hudson and Stelfox (1976) emphasized the physiological aspect of harassment in their bibliography. We have emphasized cervids in our preliminary bibliography (Gunn and Miller 1977)."

"The third category of industrial development is the great increase in the use of aircraft associated with industrial exploration and development. Espmark (1972), Thomson (1972), Klein (1973), McCourt and Horstman (1974), McCourt *et al.* (1974), Surrendi and DeBock (1976) and Calef *et al.* (1976) have described caribou responses to fixed wing aircraft and helicopters. Finally, Calef and Lortie (1973), McCourt *et al.* (1974) and Surrendi and DeBock (1976) describe some caribou responses to permanent installations such as construction camps, oil rigs and compressor stations."

"Geist (1971, 1975) in his discussion of harassment has argued for a physiological approach to harassment studies with emphasis on the energetic cost of harassment. So far, all published accounts of caribou harassment have depended on observations of behavioural responses. The reliance on behavioural responses was partly the result of most harassment studies being secondary to other projects, such studies of sex and age composition, but also was the result of the current state of remote monitoring of physiological parameters."

"These harassment studies demonstrated that caribou responded differently to harassment that coincided with the identified critical phases of their life cycle. Observations of responses to both pipeline simulations and aircraft harassment identifies a cow-calf pair as the most responsive sex-age group. The studies of aircraft harassment critically reviewed in Geist (1975) all agreed that altitude of the aircraft was one of the determinants of the responses, but previous activity, sex and age class,

group size, season, surrounding terrain and aircraft type were all considered important."

"Most studies of harassment have considered barren-ground caribou. Peary caribou are the least known caribou subspecies (Jakimchuk 1975): recent data on numbers and movements (Miller *et al.* 1977 a and b, Miller and Gunn 1978b) suggest this subspecies may be particularly vulnerable to harassment."

"There have been to date no specific studies on harassment of muskoxen by aircraft and only one study on the effects of seismic activity on muskoxen (Beak Consultants 1975). There are some descriptive accounts of responses to isolated harassments by aircraft (Gray 1974), seismic activity (Urquhart 1973, Riewe 1973, Slaney 1975) and human activity (Hone 1934, Tener 1965)."

"Geist (1971, 1975) outlined some effects of harassment primarily on ungulates and noted (1971:419) that "Another serious consequence of persistent disturbance is voluntary withdrawal from available habitat.""

Summary Discussion

"The estimates that we made of the distances that animals travelled during their locomotory responses to harassment are a measure of the intensity of their response. Our estimates of the distances moved by the Peary caribou during overhead passes suggest they rarely travelled more than 400 m. Bergerud (1963) and Calef and Lortie (1973) suggested that caribou usually moved less than 500 m when overflown by an aircraft. The distances that muskoxen moved after taking up a group defense formation varied, but were usually less than 200 m: only one group (in 1976) galloped between 200 - 400 m during passes. Although we do not understand the mechanism of group defense formation (e.g. initiation, focal point, etc.) we believe that the distances between group members (or a solitary bull from a physical feature) partially determined the gait used to take up the defense formation."

"In general, the reported results emphasized altitude is an important determinant of response levels, but group size, sex and age class, season, terrain, previous activity and aircraft type were all considered as contributing to the response levels. There were some differences in the recommended operational ceilings for aircraft to minimize disturbance to caribou. Calef *et al.* (1976:210) suggested that aircraft operating at above 150 m during spring or fall migration would avoid "most potentially injurious reactions by caribou", but during calving period, the rut and early winter, a minimum altitude of 305 m would be required. McCourt *et al.* (1974) suggested 305 m as a "minimum altitude tolerance level." Although we realize that both caribou and muskoxen have adapted to human presence (and disturbance) in certain situations, we do not understand the processes that lead up to habituation. This knowledge is critical to fostering the compatibility of the well-being of caribou and muskox populations with northern development. It is not, however, only the animals that will have to adapt: industry and government will also have to adapt their operation schedules and policies to provide opportunities for the animals to accept the changes in their environments."

In particular, we stress that lowlevel flights overhead, circling or following the animals and landings closeby animals with on-foot approaches are extremely detrimental to animals not only in the short-term, but also in reducing the likelihood of habituation. Based on our findings and the belief that there is a need for a judicious approach to the conservation of wildlife and habitats, expecially in the light of our limited knowledge of the true consequences of petroleum development of the arctic ecosystem, we recommend that all possible aircraft flights be kept above 300 m agl at all times and above 600 m agl during calving and post-calving periods (May-August) and rutting periods (August-November)."

"The setting of minimal height regulations for aircraft is not an imposition for much of the aircraft traffic that would be associated with pipeline construction, as flying at those altitudes or higher makes navigation by landmarks relatively easy and most pilots also prefer the added safety margin afforded by the higher altitudes in the event of mechanical problems. Another justification for setting minimal altitudes on the high side is the abrupt nature of much of the terrain of the Arctic Islands with its vertical rises and drops of several hundred metres. Pilots seldom compensate for the ground elevational changes unless the elevation puts them dangerously low to the ground."

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Patterson, L. A. 1974. An assessment of the energetic importance of the North Slope to Snow Geese (*Chen caerulescens caerulescens*) during the staging period in September 1973. Arctic Gas Biological Report Series 27(4). 44 pp.

Author's Abstract

"Adult and juvenile lesser snow geese were collected and dissected as they arrived and departed from their staging area on the North Slope in the Yukon Territory. During the average 17-day stay on the North Slope, body weights increased 14.3% in adult males, 17.1% in adult females, 9.5% in juvenile males and 23.0% in juvenile females. The greatest part of this increase represented deposition of fat.

The pre-migratory feeding period extends from the time the juvenile geese are able to fly until departure for the south. The fat accumulated during this period is used as a source of energy during migration. A minimum amount of fat must be stored to enable the geese to fly to the next major feeding area (Peace-Athabasca Delta). The length of the feeding period is determined by weather conditions in the spring (affect the time that the juveniles are able to fly) and the onset of winter (departure for the south).

Four areas were considered important to the snow geese during this period in 1973:

- a) the breeding grounds;
- b) Tuktoyaktuk and Bathurst Peninsulas;
- c) Mackenzie Delta,
- d) North Slope.

The relative importance of these areas varies from year to year depending on weather conditions. The North Slope was considered to be the most important feeding area in 1973. The geese increased fat reserves while they were on the North Slope in 1973 by amounts that equalled the fat accumulated prior to their arrival on the North Slope."

Discussion

"In summary, variable weather conditions in the Arctic limit the amount of time available for pre-migratory feeding by snow geese. In response to the unreliable conditions, snow geese that stage on the North Slope prior to migration have developed a flexible means of preparation for migration. The system adjusts to annual weather conditions so that the geese can feed for the entire period available to them. Such an adaptable system allows the geese to accumulate at least a minimum of fat prior to migration. Such an accumulation ensures that the geese will have enough energy to allow them to fly to the next feeding area to the south. This adaptation to a wide range of potential weather conditions remains advantageous as long as the feeding areas remain available to the geese and they are able to feed for the entire pre-migratory period."

"Cooch (1958) suggested that snow geese that migrate while in poor condition had to stop to feed more often than usual during migration. Because such frequent feeding stops rendered the migrating geese particularly vulnerable to hunters, these geese suffered a high rate of mortality. Alteration of feeding habitat in the western Arctic and the resulting reduction in feeding efficiency could combine with the future kill of snow geese by hunters to deplete the snow goose population. Such depletion would be particularly critical in years following low production of young on the breeding grounds."

"Geese are traditional birds (Newton and Campbell, 1969; Prevett, 1973). They repeatedly use the same breeding grounds, wintering areas, feeding sites, and routes of migration. Their habitual use of such areas might be difficult to alter (Lieff, 1973), although geese themselves do occasionally change their habits. The number of years geese require to change long-standing habits is, however, unknown. It is possible then, that the western Arctic population of snow geese may change feeding areas in response to any alteration of the habitats of traditional areas that might occur. On the other hand, it is also possible that this population might be severely depleted before they could complete the process involved in such a change."

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Renaud, W.E. and M.S.W. Bradstreet, 1980. Late winter distribution of Black Guillemots in Northern Baffin Bay and the Canadian High Arctic. Canadian Field-Naturalist. 94: 421-425.

Methods

"Aerial surveys were conducted in a deHavilland Twin Otter aircraft on 19 April 1977; 15-17 March and 18-20 April 1978; and 17 March 1979. Most surveys were flown at 100 - 200 m, and at an air speed of 200 - 220 km/h."

"All guillemots (*Cepphus grylle*) seen in March and most in April were in winter (white) plumage, and were conspicuous against the inky-black water of cracks and leads where they were usually seen swimming or flushing. Most guillemots more than 500m from the aircraft (and some at lesser distances), however, were probably not detected. Also, some guillemots dove as the aircraft approached and hence an unknown (but probably small) proportion of those present was undetected."

Sanger, G. A., and R. D. Jones, Jr. 1981. The winter feeding ecology and trophic relationships of marine birds in Kachemak Bay, Alaska. OCSEAP Research Unit 341. Contract 01-5-022-2538. U.S. Fish and Wildlife Service, National Fishery Research Center, Migratory Bird Section, Anchorage, Alaska. 123 pp.

Physical Disturbances (page 86)

"It is difficult to assess the possible negative effects of disturbance to the wintering birds from aircraft and boat traffic. The main problem is the lack of comparative quantitative information on "before and after" conditions on populations of birds in other areas. All of the species of birds we studied are known to inhabit other areas in Alaska and elsewhere on the Pacific Coast which have aircraft and particularly boat traffic. Chiniak Bay on Kodiak Island and Puget Sound, Washington, are two such examples. During our studies, the white-winged scoters were particularly skittish at the approach of our boat, a situation we also experienced in the Kodiak Area. However, fishermen are known to shoot marine birds for crab bait and it is possible that the scoters have learned to be wary of the approach of any boat."

Schweinsburg, R.E. 1974. Disturbance effects of aircraft on waterfowl on North Slope lakes. June 1972. Arctic Gas Biological Report Series 14(1). 48 pp.

Introduction

"This study was designed to test the effects of float-equipped aircraft on populations of waterfowl occupying the small ponds and thaw lakes of the North Slope during the breeding season. Except for the extensive channel systems of the larger river deltas, these small bodies of water are the only available habitat for many species and are important as breeding and molting areas."

"It had been empirically obvious that small planes disturbed waterfowl when landing on lakes, but it was not known to what extent."

Method

"Baseline information on species composition, numbers and behavior was gathered the first day on the large and small experimental and control lakes. Single observers were brought to each lake in a Bell 206 helicopter (without flying over the lake). They were picked up the same way at the end of the day."

"The observers were similarly placed on the ensuing days, and the experimental lakes were disturbed by a Cessna 185 at hourly intervals, starting one hour after the observers were in place and ending one hour before they were picked up. The plane taxied approximately five minutes between landing and takeoff. The numbers and reactions of the birds on the lake were recorded by the observers."

CALCULATIONS

Immediate effects of aircraft disturbance

"To test the immediate effects of aircraft disturbances on waterfowl it was necessary to compare control lakes with disturbed lakes. This was done by comparing the number of birds present on the lake during the count (2nd reading of day) immediately prior to the first aircraft disturbance of the day and the count immediately prior to the second disturbance. The control consists of 3 days on the small control lake and the first day on the small experimental lake (no disturbance on the first day). The experimental data were derived from the 4 days of disturbance on the small experimental lake."

"It is apparent from Table 1 that aircraft disturbance significantly reduced the number of waterfowl using the experimental lakes ($U = 0.0$; $P = 0.014$)."

Cumulative effects of aircraft disturbance

"The cumulative effects of aircraft disturbance on waterfowl are examined and it can be seen that the number of waterfowl decreased as disturbances

continued ($r = -1.0$; Kendall's Correlation Coefficient). In terms of the average number of birds using the lake throughout the day there appears to be a levelling-off at about 20 birds on days 3, 4 and 5. The sample size was too small to indicate the significance of the decrease in average numbers using the lake."

"It is safe to conclude that, as the number of aircraft disturbances increase, the number of waterfowl using a lake decreases at least to a certain level. This minimum level may be a function of what the waterfowl are using the lakes for. If a duck has a nest or young on the lake then it is less likely to be permanently scared from the lake. Similarly, if the duck is molting it will be flightless and incapable of leaving the lake. The effect of aircraft disturbance on these birds may not show up until the next year when they might not use the lake for nesting or molting."

Behaviour

"Quantitative behavioral data were gathered on two major activities - sleeping and feeding. It was hoped that by comparing the time the birds spent engaged in these activities on undisturbed days with the time spent on disturbed days, we could discover whether the normal behavioral activities of the birds were affected by the aircraft. The undisturbed day on each of the experimental lakes was to act as a measure of the normal behavior. Later analysis of the data indicated that the single undisturbed day did not cover a long enough period to encompass a sufficient number of normal conditions which might affect behavior patterns (e.g. weather)."

"Bearing in mind these limitations of the data obtained, several examples of possible disruptions in regular behavioral patterns are presented. Our comments must perforce be considered highly tentative, but it seemed that in many cases the feeding and sleeping activities of the birds became extremely irregular. Generally, the same amount of time was allotted to each activity during disturbed and undisturbed days, but on disturbed days the pattern seemed far more erratic."

Discussion

"The most conclusive data in this study came from the small experimental lake. The population of waterfowl on this lake was reduced by 60% during the four days of disturbance. A degree of accommodation was reached during the last two days of this study, but not until significant population disruption had already occurred."

"There was also a general population decline of the large experimental lake but the reduction was not as marked as on the smaller lake."

"It remains to be tested whether or not large lakes will accommodate a greater degree of disturbance than will small ones. Certainly on the larger lakes, the waterfowl have more room to avoid the aircraft and hence are possibly less prone to completely abandon the area. This has been shown for arctic and red-throated loons in response to human disturbance on the coastal tundra of Hudson Bay (Davis 1972). It should be pointed out that the species composition varied between lakes of different sizes and depths."

Ducks from larger, deeper lakes may be dependent upon a food supply which can be obtained only in the deeper water so that, when they are forced to repair to shallower regions to escape the movements of the aircraft, they are in effect losing access to their best feeding areas. More study, possibly using more than one observer, will be necessary in order to ascertain to any degree of confidence the effects of aircraft disturbance on the larger lakes."

"It appears certain from our studies that the birds on different lakes, even of relatively the same size (e.g. small experimental and intermediate experimental), vary in their ability to adjust to aircraft disturbance. Lakes affording areas of protection such as marshes or shallow bays may be better suited to withstand sustained pressure."

"Further, in order to accurately determine the effects of disturbance, it is necessary to learn more about the normal behavior of waterfowl in undisturbed conditions. Daily cycles in population-levels on the various water bodies are not sufficiently understood. It is likely that many birds come in to feed on the larger lakes at various times during the day, possibly returning to the smaller lakes sometime towards evening. Trends of this nature were noted in this study, but because of the exceptionally late season and the manpower demands of other studies, the time available in 1972 was insufficient to allow us to gather enough baseline data."

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Schweinsburg, R. E. 1974. Snow Geese disturbance by aircraft on the North Slope. September 1972. Arctic Gas Biological Report Series 14(7):258-279. 22pp.

Introduction

"Casual observations made during waterfowl surveys indicate that light aircraft disturb resting snow geese. Upon approach of the aircraft, the geese exhibit obvious flight avoidance reactions. It is possible that frequent disturbance of this nature could alter normal habits and behavior sufficiently to cause long-term consequences to snow goose populations."

"One of the most probable areas of snow goose disturbance by aircraft is on the North Slope of Alaska and the Yukon Territory. In this area snow geese flock by hundreds of thousands from August 15 to about September 15 (Bartonek 1969, T. Barry pers. comm.). Here they feed and store energy for the impending southern migration. The part of the North Slope which the snow geese use is relatively narrow and includes the proposed right of way of the gas pipeline (Figure 3). Frequent aircraft flight during the construction and operation phases could disturb feeding behavior if they occur during the period when geese are on the North Slope. This could have serious consequences on migratory success."

Discussion

"Workers studying the development of northern oil fields and their impact on bird populations appear to have been primarily concerned with oil and oil pollution (Brooks *et al.* 1971; Bartonek *et al.* 1971), and only secondarily with disturbance created during production and transportation activities. However, concern should also be expressed about effects on populations created by long-term exploration, development and production. This may prove to be more detrimental than pollution problems, particularly in the case of a gas pipeline, whose major impact may be animal disturbance, rather than pollution."

"Short-term and long-term effects of man's disturbance to arctic wildlife populations are poorly understood and only recently of concern to biologists. As a result, existing literature on the subject is sparse and the impact which has occurred has not been documented."

"It is clear from this study that snow geese on the pre-migratory staging grounds can be disturbed by aircraft at elevations up to 10,000 feet. The significance of this in the short-term is not clear, as no attempts were made in this study to determine accommodation to disturbance or the cumulative effects of overflights. The long-term effects of disturbance to geese on the staging grounds are difficult to anticipate without long-term studies but the possibility exists that energy storage may be seriously affected by disturbance. This could affect migratory success. Frequent disturbance might cause large areas to become unacceptable for resting snow geese. Consequently, because snow geese are traditional in habits (Barry 1967),

this could have significant effects on future populations. Until further evidence becomes available, extreme caution should be exercised in control of the number and routing of aircraft flights during the period snow geese are using the North Slope for their pre-migratory resting and feeding. There is no practical flight altitude that does not frighten snow geese. The possible loss of habitat due to aircraft disturbance adjacent to the pipeline right of way would be difficult to detect, making careful monitoring essential."

Conclusions and Recommendations

1. "Overflights by a Cessna 185 disturbed all resting snow geese at altitudes of 300, 700, 1,000, 5,000, 7,000 and 10,000 feet."
2. "Geese tend to flush at greater distances when the aircraft is under 1,000 feet."
3. "Flocks flush as much as 9 miles away from the aircraft."
4. "There is no apparent relationship between avoidance behaviour and flock size."
5. "Geese can be driven from an area roughly 50 miles square within 15 minutes by 'hazing' with a Cessna 185."
6. After severe disturbance, flock sizes are reduced with consequent increase in the number of flocks.
7. Because of the sensitivity of geese to aircraft disturbance, flight should be curtailed over the pre-migratory staging areas between August 15 and September 30 and necessary overflights during this time should avoid areas of heavy snow goose concentration.
8. Studies should be conducted to determine lateral distance disturbance thresholds, possible accommodation by geese to disturbance, possible cumulative and long-term effects of disturbance to geese, and reactions of geese to other types of aircraft.

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- Schweinsburg, R. 1976. Polar Bears - Research in and around Admiralty Inlet. July - August, 1975. Pages 19-61 in Environmental Baseline Studies 1975. Strathcona Sound Program Preliminary Report.
B. Kempes, ed. C.W.S. unpubl. rep. C.W.S.35-76, Edmonton, Alta.

4.7 Effect of Man's Activities on Bears P. 48

"Unless chased, polar bears did not seem to be greatly disturbed by helicopters; often bears were seen in the same area several hours after the helicopter had left."

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"The extent to which increased human activities will affect the viability of Brodeur and Borden peninsulas as a summer sanctuary for polar bears is unknown. In the absence of this knowledge, it would be wise to restrict human activities in the summer sanctuary from July until freezeup. Human activities in this area should be permitted only if it is conclusively proven that such activities will not impair the usefulness of the area to polar bears. The probability of man-bear conflicts should be carefully considered in the establishment of camps or other facilities in a summer sanctuary. It is interesting to note that the present distribution of Inuit summer hunting camps in both Admiralty and Navy Board inlets begins at the point where polar bear summer distribution ends. Either the polar bears and the hunters have learned through conflict and traditional use of areas to avoid each other or the two species occupy different niches during the summer. The distribution of polar bears previous to the establishment of Arctic Bay and Nanisivik Mine is unknown, but it is worthy of note that on the west coast polar bears are distributed south almost to Yeoman Island, but that their distribution southward on the east coast stops at Strathcona Sound."

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"Although the potential impact of human activities on polar bear populations has not been precisely determined, Stirling, *et al.* (1975) point out the need to protect polar bear feeding and breeding habitat from industrial activity until more is learned of man's impact on polar bears. Moreover, Jonkel (1975) points out that the bears of Admiralty Inlet could be affected by oil spills, chemical contaminants, disruption of food chains, disturbance to maternity denning areas, the proliferation of general human activities, and disturbance to summer sanctuaries (land or ice areas used by polar bears during the minimum ice periods). However, little is presently known of the feeding areas, breeding areas, or summer sanctuaries of polar bears in the Admiralty Inlet-Navy Board Inlet area."

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Schweinsburg, R. E., M. A. Gollop, and R. A. Davis. 1974. Preliminary waterfowl disturbance studies, Mackenzie Valley, August 1972. Arctic Gas Biological Report Series 14(6) Chapter 6, pages 232-257.

Introduction

"The Mackenzie River Valley represents an important transportation corridor for materials bound for northern settlements. Although future northern development will undoubtedly mean greater use of the valley by shipping, highway transport, and possibly railway, aircraft will probably continue to be the most utilized transportation form for some time to come."

"Frequent use of small lakes by light aircraft may have adverse effects on local waterfowl populations, depending on the degree of use by aircraft, and the density and composition of waterfowl species at varying times of year."

"Preliminary experiments were conducted on two lakes in the Mackenzie Valley area to determine the reactions of waterfowl to repeated aircraft disturbance in late summer. In addition, waterfowl counts were made at the Department of Transport float base at Norman Wells, which is subject to heavy air traffic all summer, and on the lake immediately to the east-southeast, which is on the path of low-flying aircraft approaching or leaving DOT lake."

Implications of Disturbance

"Some preliminary remarks can be made on the implications of disturbance to waterfowl at this time of year. Some waterfowl apparently become tolerant of aircraft activity, as our results from DOT lake at Norman Wells show. This lake supported a relatively low density of waterfowl (80 per sq. mi. compared to peak densities of 250 per sq. mi. on Lake 1, 560 per sq. mi. on Lake 2, and 215 per sq. mi. on the second lake at Norman Wells), but the lack of apparent reaction from the birds indicates that small numbers of birds, at least, are able to withstand repeated disturbance."

"There was a difference in the response of waterfowl to aircraft disturbance on the two experimental lakes. On Lake 1, which was essentially a brood-rearing lake, the number of birds did not decrease as aircraft disturbance increased ($r = +0.359$; $n = 5$; Table 1, Kendalls rank correlation--Sokal and Rohlf 1969). However, on Lake 2, which was used by molting and non-breeding birds, there was a marked reduction in the number of birds using the lake as disturbance continued ($r = -0.900$; $n = 5$; Figure 10, *ibid*). This indicates that females with broods did not avoid the disturbance by flight whereas non-breeding birds did."

"Our studies were conducted on small lakes in order to facilitate the observation of waterfowl behavior. The data indicate that, for some species at least, reaction to disturbance depended on the proximity of the aircraft. Any deleterious effects might therefore be reduced on larger lakes."

Smiley, B.D., and A.R. Milne. 1979. LNG transport in Parry Channel. Possible environmental hazards. Institute of Ocean Science, Patricia Bay, Sidney, B.C. Unpublished Manuscript, 47pp.

8. Wildlife and LNG Icebreakers in Parry Channel

8.1 Seabirds Page 27

"There exists a potential hazard to seabird colonies at Cape Hay, Hobhouse Inlet, Cape Liddon, Prince Leopold Island and Browne Island unless the LNG carriers are routed away during the egg-laying and chick-rearing periods. Seabird colonies should be given the same consideration as centres of population. The same strict measures and criteria of "safe distance" should apply. If LNG carriers pass close to these colonies, possibly within 1 or 2 km, the vessel's noise and physical presence could initiate a hasty and confused mass exodus of brooding birds from the nesting cliffs. Eggs and young chicks would be dislodged, accidentally, into the water. Unprotected eggs and chicks would fall prey to glaucous gulls and other aerial predators. The ship's noise may also cause fulmar, kittiwake and murre chicks to fledge prematurely. The resultant cumulative mortality to the colony's brood could be significant. Another, though less probable threat as a result of the vessel's normal operations is the "boil-off" of natural gas near the seabird colonies - to which birds would be extremely sensitive. In fact, birds are often biological indicators of very low concentrations of toxic gases, such as methane and ethane. With light onshore winds and under temperature inversion, vapours from a nearby-passing LNG carrier could kill instantly large numbers of nesting seabirds and chicks. To minimize such threats of noise and air pollution, LNG carriers should travel well offshore in Parry Channel from April to October, thus avoiding seabird-colony locales, and most coastal feeding areas."

Stalmaster, M.V. and J.R. Newman, 1978. Behavioral responses of wintering Bald Eagles to human activity. J. Wildl. Manage. 42: 506-513.

Author's Abstract:

The effects of human activity on wintering bald eagles (*Haliaeetus leucocephalus*) were studied in Washington for 2 yr. Tolerance to disturbance was determined by analyzing eagle distribution in relation to human activity and by measuring flight distances of eagles from simulated human disturbances. Human activity was found to affect eagle distribution and behavior adversely. Distribution patterns were significantly ($P < 0.001$) changed, resulting in displacement of eagles to areas of lower human activity. Older birds were more sensitive ($P < 0.001$) to disturbances. Flight distances were highest for simulated disturbances in water and on gravel bars, intermediate on land, and shortest under a vegetation canopy. Habituation to normal activities seemed to occur. Reduced human interferences, creation of vegetation buffer zones, and establishment of activity restriction zones are recommended for wintering grounds.

Introduction

"Declines in bald eagle populations have been attributed, in part, to direct human disturbance (Sprunt 1969). Urban sprawl, recreational developments, and increasing outdoor activity in prime eagle habitat have directly and adversely affected the bald eagle (Sprunt and Ligas 1966). Evaluations of the effects of disturbance on nesting eagles are difficult to generalize. Mathisen (1968), Grier (1969), Grier and Fyfe (in press), and Newman *et al.* (1977) found no evidence of human activity disrupting reproductive success. Juenemann (1973) and Grubb (1976a), however, have shown an indirect relationship between human activities and nesting success. Concern over the sensitivity of wintering populations to human interferences has also been expressed (Shea 1973, Servheen 1975, Steenhof 1976, Spencer 1976, Stalmaster 1976). Quantitative information of the avoidance responses of eagles to disturbance is lacking. The purpose of this study was to measure the effects of human disturbance on the behavior of bald eagles in northwest Washington.

Results

"Disturbances in high activity units were beyond the tolerance limits of most wintering eagles. Moderate human activity seemed to be tolerated; however, the shift in distribution resulted in a greater number of birds displaced to marginal habitat and confined the population to a smaller area. Since the major feeding grounds were disproportionately located in high and moderate human activity units, the number of birds in low activity units was lower than expected. On the Nooksack River, the shift in distribution was evident only in high and moderate units and prevented effective use of all."

"Human activity had a significant influence on the feeding behavior of eagles. Mathisen (1968) stated that human activity could interfere with food gathering and possibly cause general unrest among an eagle population. However, Steenhof (1976) suggested that tolerance levels were high

on preferred feeding sites. Feeding behavior on the Nooksack was disrupted by the mere presence of humans. Disturbed birds did not return to the same feeding area until several hours after the disturbance occurred and only when the disturbance no longer persisted. Compared to other eagle activities, feeding birds were most sensitive to human interferences."

"A comparison of juvenile and subadult to adult distribution indicated a significant difference in tolerance to existing human activities (Tables 2, 3). Adults were more sensitive to disturbance than younger birds and preferred units of lower activity. Proportions of adults were lower in areas where activity was particularly prevalent."

"Repeated disturbances were made to the same individual in several instances. Responses were similar in both the flight distance and the distance of the avoidance flight."

"Normally occurring auditory disturbances were not unduly disruptive to eagle behavior. Gunshots were the only noises that elicited overt escape behavior. Edwards (1969) found that gunshots could be used effectively in flushing birds from their roosts. Eagles were especially tolerant of auditory stimuli when the sources were partially or totally concealed from their view."

Discussion

"Habituation to Activity.—Wintering eagles can become habituated to routine human activities. Birds on the Nooksack were more easily disturbed by approaches that occurred on the river channel than from adjacent farm meadows where activity was common."

"Habituation is the temporary or permanent waning of responsiveness by animals to repetitious stimuli (Marler and Hamilton 1966:642-644). In bald eagles, habituation to human activity has been suggested by Grier (1969) and Edwards (1969). Grier contended that birds accustomed to activity were less disturbed by next climbing. Edwards found that approaches could be made closer at roosts which were closer to usual activity. Eagles on the Nooksack were also easier to approach when the approach was made from areas regularly high in activity (*Riverbank*)."

"Tolerance to human activity is related to the location of the disturbance. Our data indicated that activities involved directly on the channel of the river, such as boating and fishing, were most disturbing if activities did not regularly occur there. Normal daily activity patterns were changed by human presence."

"Activity restriction zones are suggested for bald eagle wintering grounds. In open regions where activities are common (*Riverbank*), boundaries of 250 m would be sufficient to protect 99 percent of the population (Table 4). Similarly, boundaries on river channels of 250 m would protect 90 percent of the birds. A combination of both activity restriction zones and vegetation buffer zones is desirable. Establishment

of sanctuaries with these elements is encouraged. Variations of tolerance between populations is likely; therefore, we suggest monitoring of adult eagle behavior in development management recommendations since they are most sensitive to human presence."

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Steenhof, K. 1976. The ecology of wintering bald eagles in southeastern South Dakota. M.S. Thesis. Univ. of Missouri, Columbia. 148 pp.

Stott, R.S. and D.P. Olson, 1972. An evaluation of waterfowl surveys on the New Hampshire coastline. J. Wildl. Manage. 36: 468-477.

Author's Abstract:

Fifteen simultaneous air and ground censuses of eight species of wintering sea ducks were conducted on a 22-mile section of the New Hampshire and Massachusetts coastline during 1968-71. In comparison with surface counts, there was extreme variation in the aerial survey results even with identical aircraft, weather conditions, and observer. These discrepancies cast serious doubt on the usefulness of the aerial survey technique as an indicator of population trends of sea ducks. Size of aircraft, amount of cloud cover, and surface of ocean influenced the accuracy of aerial surveys, but these factors accounted for only a small part of the variability. A system of ecologically stratified ground censuses is recommended as an alternative to or a modification of the present aerial survey technique.

Goldeneye and Red-breasted Mergansers P. 473

"These two species were combined (Table 2) because they occurred together in groups, used the same habitats, and had similar black and white or brown and white plumage with nearly identical wing patterns. When approached by low-flying aircraft, these species consistently flushed and flew away from the aircraft or towards the ocean until they were about to be overtaken. At this point, they either flew back under the aircraft or circled back away from the aircraft and landed on the water close to their original location. This behavior was observed consistently from the air and confirmed on many occasions from the ground."

"The noise level or size of the aircraft, or both, affected the accuracy of aerial counts of these species (calculated $t = 2.275$, significant at 90 percent level with 8 df). The Cessna was the quieter of the two aircraft used, as determined by ground observations and also by engine horsepower (Cessna 100 hp, Beaver 450 hp). The Beaver, with floats, was approximately twice the size of the Cessna and was probably more noticeable to waterfowl than the Cessna. The average percentages counted from the air were 78.0, range 55.5 to 110.1 percent and 62.1, range 42.9 to 82.1 percent, for the Cessna and Beaver, respectively. With the de Havilland Beaver, the goldeneye and red-breasted mergansers flushed sooner and were often too far in front of the aircraft for accurate counting. With the Cessna, these birds flushed later and were closer in front or to the side of the aircraft, where they could be more readily counted. During the aerial survey, it was possible to fly the Cessna more slowly (90 mph) than the Beaver (110 mph). The slower air speed was more important with this group, which consistently flushed, than with the scoters that did not flush at all."

Oldsquaw

"Ground observations revealed that these birds were the most active of the sea ducks, constantly flying about and diving to feed, and this behavior

may explain the large discrepancies in the aerial surveys of this species. On one aerial survey it was noted that as the aircraft approached small groups of oldsquaw they dove underwater. Oldsquaw, like the scoters, seldom flushed from the water when approached or flown over by either the Cessna or the Beaver."

Discussion

"The results cast serious doubt on the usefulness and reliability of the aerial survey technique as an indicator of population trends of sea ducks. It is doubtful that additional air and ground comparisons would be of value because of the consistent variability of the present data and the nature of the factors (degree of overcast, surface of ocean, and size of aircraft) that affected the efficiency of our aerial surveys."

Thompson, B. C. and B. W. Baker. 1981. Helicopter use by wildlife agencies in North America. Wildl. Soc. Bull. 9(4):319-323.

Agency Comment (p. 322)

The greater disturbance associated with helicopters remained a controversial point. Although the flushing effect has been used to an advantage in censusing (Kufeld et al. 1980), and disturbances have been neutral during surveys with both types of aircraft (Buckley et al. 1977, Kushlan 1979), Missouri indicated that disturbance was an important reason for minimizing helicopter use. Alaska cautioned that disturbance must be considered when working with or near alpine species that could suffer accidental falls.

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Kufeld, R. C., J. H. Olterman, and D. C. Bowden. 1980. A helicopter quadrat census for mule deer on Uncompahgre Plateau, Colorado. J. Wildl. Manage. 44:632-639.

Kushlan, J. A. 1979. Effects of helicopter censuses on wading bird colonies. J. Wildl. Manage. 43:756-760.

Ward, J., and P. L. Sharp. 1974. Effects of aircraft disturbance on moulting sea ducks at Herschel Island, Yukon Territory, August 1973. Arctic Gas Biological Report Series 29(2). 54 pp.

Authors' Abstract

The objective of this study was to compare the behaviour of moulting sea ducks under undisturbed and disturbed conditions.

The study area was located on the south shore of Herschel Island, Yukon Territory; the time of the study was August 2 to 15, 1973. The study was conducted from two camps: one (Herschel West), where for parts of three of the 14 days a helicopter flew over every hour at an elevation of 100 meters, and the other (Herschel Control), where the ducks were not disturbed.

The observers recorded bird species, numbers and sizes of flocks, distances between flocks, the distances of flocks from shore, activities of birds, and reactions to disturbance. Records were made hourly between 0600 and 2100 of every day. Only oldsquaw and surf scoters were present in numbers sufficient to permit significant conclusions to be drawn.

It was concluded that:

- 1) similar disturbances made in 1972 for study purposes did not affect the number of birds using the area for moulting in 1973;
- 2) helicopter disturbances at 100 m altitude have an immediate, but no apparent lasting effect on bird behaviour;
- 3) helicopter overflights don't drive birds from the area;
- 4) helicopter overflights at 300 meter altitude did not affect the behaviour of moulting sea ducks;
- 5) helicopter disturbances don't affect the average flock size or flock types, or the feeding activities of moulting oldsquaw and Surf Scoters.

Discussion

"The reaction of the birds to the helicopter is certainly related to the distance between the helicopter and the birds. In 1972, it was found that birds started to respond to helicopters that were flying at 750 feet (= 229 metres). When the helicopter was at an altitude of 100 feet (= 30.5 m), entire flocks would dive in response to the overflight."

"Based on the results of 1972 and 1973, flights of helicopters at 1000 feet (= 305 metres) or higher should have no effect on moulting sea ducks at Herschel Island. Flights at altitudes lower than 750 feet (= 229 metres) would affect the birds; but if the helicopter maintains a normal cruising speed (= 193 km/hr), the effects should not disrupt the moulting activities of the birds in this area."

White, C. M., and S. K. Sherrod. 1973. Advantage, and disadvantage, of the use of rotor-winged aircraft in raptor surveys. Raptor Research 7(3/4):97-104.

Author's Abstract:

We believe that the advantages of aerial survey with helicopters far outweigh the disadvantages. Disturbance may be less than that caused by entering on foot. Statistical validity is greatly increased as is understanding of the gestalt of the population.

Although other raptors may react in a different manner to helicopter observations, our impressions are that little damage is done by aerial vehicles used in the manner we have described for collecting data from the raptor species we have mentioned.

Additionally one should be aware that although the cost, on a per hour basis, for helicopters may be considered expensive, it may prove no more expensive than the cost of outfitting and supporting a field party when the differential of time and efficiency are compared.

Introduction

"Fixed-winged aircraft and rotary-winged aircraft(helicopters) are available today for use in censusing raptor populations. Indeed the latter type has been used rather extensively with the opening up of northern regions in the course of mineral and oil explorations. Along with their use, however, has come considerable criticism sometimes justified, but more often than not from people who have never used one for such work. Due to our limited experience with fixed-wing aircraft, the following remarks are primarily confined to both advantages and disadvantages of using rotary-winged aircraft for observations of raptor populations. We have tried to be unbiased in our observations and to present the data as we see it. Our impressions are based upon a total of 888 hours of helicopter usage in Interior Alaska, on the North Slope, and in the Aleutian Islands from 1969 to the present, and an additional 50 hours in 1964 on the North Slope. Species that have been observed are the Bald Eagle (Haliaeetus leucocephalus), Golden Eagle (Aquila chrysaetos), Peregrine Falcon (Falco peregrinus), Gyrfalcon (Falco rusticolus), and Rough-legged Hawk (Buteo lagopus).

Our experience is also limited to work with raptors nesting off cliffs or hillsides in open terrain and not with tree nesting species. We hope that such people as D. Roseneau, T. Ray, E. Boeker, L. Crowley, J. McGowan and J. Gerrard will also record their observations for they have worked with either fixed-wing aircraft or tree-nesting species. Once this is done, we might then come up with a more realistic evaluation of the impact the use of aircraft seemingly has on raptors. We recognize that different groups of birds react in different manners. For example, Snow Geese (Chen caerulescens) are particularly sensitive to aircraft, especially fixed-winged, and we must stress that our remarks should not be taken as applying to birds in general."

Types of Aircraft

"Helicopters are preferable over fixed-wing craft in many cases. They allow more time for observing habitat therefore spotting birds. Many times it is necessary to hover in mid-air while making an accurate census count or while searching a cliff for a nest ledge.

Helicopters are primarily divided into two kinds: Jet engine powered, and piston engine powered. The high frequency whine made by some of the jet engine helicopters seems to be much less disturbing to nesting raptors than the low frequency noise of the piston-powered craft.

We have experience with the following aircraft: Sikorsky S-56, Hiller 12-E4, and two Bell helicopters of unknown models, all piston driven; Alouette II, Alouette III, Hiller FH 1100 and Bell Ranger, all jet engine-powered. Of these we prefer Hiller FH 1100 since noise levels seem least disturbing to raptors and there is sufficient power to maneuver in and out of wind drafts around cliffs."

Conclusions

"At present we do not feel that the data support the allegation that helicopters are a source of reduced productivity in certain raptors at the population level. Some data are as follows.

On Amchitka Island helicopters have been used for five years to census raptors. On average, 66% of nesting attempts by Peregrines are successful in fledging young. A sample of 63 nesting attempts in 1939-1940 in New York and on the British Coast had 60% of the attempts to produce young (Hickey and Anderson, 1969). Other information is also available. Data for Bald Eagles are as enlightening. Egg production for Amchitka is 1.91 egg per nest and in Southeast Alaska and parts of British Columbia, Canada, where helicopters were not used in the studies, production was 1.97 per nest (F. Robards and J. King, mimeo. report U.S.F.W.S. for 1966; D. Hancock, pers. comm.). Percent of territories with young were about 55% in Ontario (J. Grier, pers. comm. 1971), about 64% in Saskatchewan (D. Whitfield, J. Gerrard and W. Davis, Mimeo. report, 1969), about 58% in Kodiak Alaska (Hensel and Troyer, 1964), and for Amchitka in 1972, about 60%. Helicopters were not used in the first three studies. Fledging success for active nest shows a similar conformity when comparing yearly variation. For Ontario between 0.73 and 0.89 young fledged per active nest (Grier, pers. comm.), between 0.62-0.93 for Kodiak (Hensel and Troyer, 1964), and for Amchitka 0.85 for 1972. These values are all in the same ball park for both these studies in which helicopters were not used and used.

Perhaps the best over-all helicopter, at least the one that appears to be least frightening to raptors, is the Hiller FH 1100. As we have shown (Figs. 1, 2, 3, 4), pictures have been taken from the Hiller of adult Peregrines, Golden Eagles, Gyrfalcons and Rough-legged Hawks while feeding large downy young, and the adults have not flushed even though approached to within 60 ft (18m) at the same level as the nest."

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Wiseley, A. N. 1974. Disturbance to Snow Geese and other large waterfowl species by gas-compressor sound simulation. Komakuk, Yukon Territory, August-September 1973. Arctic Gas Biological Report Series 27(3). Chapter III, Pages i-vii. 36pp.

Author's Abstract

In late summer, 1973, the responses of snow geese and of other waterfowl to the sound of gas compressor simulators were studied at Komakuk, Yukon Territory. The primary objective of this study was to obtain further information concerning (1) whether migratory flights of snow geese along the Arctic coastal plain are affected by the sound and (2) whether geese eventually accommodate to this disturbance and feed in areas adjacent to the source of this disturbance.

Although reduced from its maximum volume, the noise of the sound simulators caused geese and swans to break their flight formations, to flare, to increase their altitudes of flight, to increase calling behavior, to increase or decrease their speed of flight, and to land. Geese that were both vertically and horizontally nearer to the simulators reacted to sound disturbance more frequently than birds farther away. With a single exception, feeding flocks of geese approached no closer than 800 m ($\frac{1}{2}$ mile) to the simulators' north side (where the most intense sound was directed).

Introduction

"Transportation of natural gas by a pipeline from Prudhoe Bay to destinations in southern Canada and the United States will require a succession of gas compressor stations at 50-mile intervals along the proposed route. It is possible that 30,000 hp engines and 27,500 hp refrigeration units used to move the gas along the pipeline on the North Slope will generate noise sufficient to affect the behaviour and reproduction of several species of birds near each station. Because snow geese in particular use the Arctic Coastal Plain for staging during late summer, these geese could be affected by this noise. While in this area, the snow geese feed intensively and build energy reserves they use during migration (Patterson, 1974). It is possible then that such disturbances to feeding snow geese will affect their use of the North Slope."

"Gollop *et al.* (1974) found that the simulated noise of a gas compressor station prevented geese from feeding within 2.5 km (1.5 mi.) of the simulators' position. In their experiment, decoys were used to attract the geese, but the possibility exists that the effect of the decoys may have been negative. Thus, a study of reactions of geese to the sound emitted by gas compressors under circumstances of normal operation was needed."

Methods

"Two sound simulator units (designed by J-Mar Electronics Ltd. [Toronto, Ontario] to simulate the sounds of a gas compressor station) were positioned

15 m apart and approximately 200 m from the southeast corner of the unnamed lake situated one mile south of the Komakuk DEW line site (Figure 1). With the exception of sounds of the refrigeration system, each of the units produced the types of sound normally emitted from the compressor station (for detailed description see Gollop *et al.*, 1974). Together, the two units normally produce the equivalent volume of sound of a 20,000 hp gas compressor station. However, during this study, approximately half of the sound production modules in each unit were inoperable, and the effective volume of sound from both was equivalent to the production of only one unit."

Discussion

"In addition to the study herein reported, the reactions of snow geese to the simulated sound of a gas compressor were studied by Gollop *et al.* (1974). The results of the two studies are comparable. In both studies, geese did not feed in areas where intense sound was present. This was found by Gollop *et al.* (1974), although they had decoys positioned within 400 m of the simulators. They observed that the geese only approached to within 2.5 km of the simulators (with only one simulator operable), whereas during our study (with presumably similar noise levels) they came to within 800 m of the simulators. Several factors could have caused this difference. Our study occurred over a longer time span and possibly allowed for more accommodation to the sound by the geese. There were differences in topography between the two study areas, and this could have caused differences in dispersal of sound. During the previous study (Gollop *et al.*, 1974), geese may have been wary of the decoys. In spite of these differences, the important fact is that in each study the geese demonstrated that a distance threshold from the simulators existed within which they would not feed."

"Although this experiment was designed specifically to test the reactions of snow geese, the reactions of other species were also recorded. We found that white-fronted geese, Canada geese, and whistling swans reacted similarly to the sound. That other species of birds did not show as great an avoidance reaction as other waterfowl species may be largely explained by the hunting pressure on waterfowl. Both the Inuit in the North and the numerous recreational hunters along the southerly migration routes of the geese undoubtedly condition these birds to avoid human presence and to react quickly to any loud noises. The intense sound encountered suddenly by the geese and swans in this study could perhaps be comparable to situations in which flocks come under fire, thus resulting in the reactions we observed."

"The important effects of gas compression sound on snow geese are the following: (1) the exclusion of geese from areas on which they could potentially feed on the North Slope, and (2) the expenditure of energy by geese to avoid the noise."

"Koski and Gollop (1974) indicated that areas of snow goose concentration on the North Slope are extensive (approximately 900 mi² [2350 km²] in 1973) and scattered and that these areas varied from 1973 to 1974 (W. Koski pers. comm., 1974). It appears, then, that because a large proportion of the area of the North Slope is useful to these birds, extensive feeding areas will be available despite the presence and sound of the compressor stations."

"It appears, then, that the extent of feeding areas likely to be pre-empted by the presence and sound of compressor stations will be minor in relation to the total area used by snow geese on the Alaska-Yukon North Slope. However, the effects of gas compressor stations upon snow geese should be considered not singularly but as contributors to a net effect that will possibly result from all sources of disturbance."

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INVESTIGATOR DISTURBANCE

Acoustical Society of America. 1981. San Diego workshop on the interaction between man-made noise and vibration and arctic marine wildlife. 23-29 February 1980. A report and recommendations. Subgroup appointed by the Coordinating Committee on Environmental Acoustics. 84 pp.

Introduction and Background

"The large scale development of energy sources in the coastal regions of Alaska is introducing new factors into the environment, including those of man-made noise and vibration. These regions support a rich fauna, including endangered marine species such as the bowhead whale, an important part of the Eskimo's subsistence and culture. There is considerable concern about the potential effects of industrially related man-made noise and vibration on the fragile ecosystem of this harsh northern environment. It is of critical importance to the Nation that development of this area be based on the best possible information in order that environmental effects be minimized."

"The effects on humans of harmful or annoying man-made noise are comparatively well understood. The numerous investigations into the acoustic characteristics of the various noise sources and how they affect our bodies and daily lives have involved experts from a wide range of disciplines who are occupied with the challenging problems of research and remedial measures. The rapid development of modern industrial technology has created such a noise environment for the human organism that governmental regulation has become necessary in most highly developed countries. Two of the larger noise regulatory groups in the U.S. are the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA)."

"Arctic wildlife is important, both ecologically and for the humans who rely upon it for shelter, food, clothing, cultural and aesthetic value. Unlike humans, animals do not have the capability of controlling their natural environment; they either adapt or become extinct. There is no place in the United States similar to northern Alaska where there is such reliance upon the harvesting of wild animals for food, nor such complete integration of many of those animals into the culture of the native people. Their concern has already emerged in the form of several lawsuits by the Arctic coast villages that, for example, have challenged the construction of artificial oil drilling islands in the path of migrating bowhead whales. Additionally, there is deep concern over potentially harmful effects on marine animals of man-made noise and vibration connected with petroleum exploration, drilling, production, and servicing operations. Native villages along the Beaufort Sea are involved with several species that could be affected, including the bowhead and beluga whales, ringed, spotted, and bearded seals, the polar bear, and marine birds."

"Provided with this two-day background of information (see Appendix II for abstracts submitted by participants), the writing group collectively prepared the following observations and recommendation."

I. Biology and Bioacoustics

Marine Birds (p. 3-4)

"A large variety of marine-associated birds occurs in the Beaufort Sea area and in the general vicinity of the proposed Beaufort lease sale area. The only species of rare and endangered bird occurring in or near the lease area is the peregrine falcon. Individuals of this species occur sporadically along the coast from spring through fall, with the largest numbers during the September migration. There is no current evidence of acoustic disturbances of peregrine falcons in or near the Beaufort lease sale area."

"Only three species of birds (common eider, snow goose, and oldsquaw) have been identified as possibly being sensitive to man-made acoustic disturbance. They also represent other ecologically similar species that are usually associated with, and are present in, the area of concern in smaller numbers or for a shorter period of time than the three key species. For instance, glaucous gulls, Arctic terns, and Sabine's gulls all nest on gravel barrier islands similar to those used by common eiders. Each species may be affected by acoustic insult in a manner similar to that of common eiders."

"Surf, white-winged, and black scoters, common and king eiders, and red-breasted mergansers all concentrate in small numbers in coastal lagoons in or near the lease area. All are associated with the much more abundant oldsquaw duck, and may be similarly affected by man-made noise."

"Nesting snow geese are uncommon along the Alaskan Beaufort Sea coast, but from 15 August to 30 September, hundreds of thousands concentrate on the tundra east of the lease area, in the Arctic Wildlife Range. This species has been reported to be very sensitive to aircraft disturbance."

"Common eider, *Somateria mollissima*. The common eider is one of three very abundant species of gregarious seaducks that winter in the North Pacific and Bering Sea and migrate into the Beaufort Sea area in late April through mid-June. They nest primarily on gravel-covered barrier islands and rear their young in coastal marine habitats. The males leave the Beaufort Sea during their molt migration in July and August. Females and young-of-the-year remain in coastal marine habitats of the Beaufort until freeze-up during late September through October, after which they migrate to winter quarters in the north Pacific and Bering Sea. The seaducks are important in the culture and economy of local residents along the Beaufort Sea."

"Disturbance of nesting common eiders has been documented at various locations in the Beaufort Sea area and recently at a location in the lease area. The disturbances were caused by low-flying, small, fixed-wing aircraft and by helicopters directly over the nesting area during the egg-laying and incubation periods."

"Lesser Snow Goose, *Anser caerulescens*. The nesting colony of these birds on Howe Island (delta of the Saganirktok River) is the only colony of this species remaining in the United States. Their wintering area is presently unknown; however, lesser snow geese nesting on Banks Island, Canada, approximately 740 km east of Howe Island, winter in the Great Central Valley of California. Those nesting on Wrangell Island, USSR, approximately 740 km west of Howe Island, winter in the Fraser River delta - Puget Sound region of British Columbia and Washington."

"Recent experiments and experience have shown that lesser snow geese are very sensitive to aircraft disturbance. The most recent and serious disturbances were caused by low-flying helicopters, directly over the nesting area on Howe Island, during egg-laying and incubation."

"Oldsquaw ducks, *Clangula hyemalis*. The oldsquaw duck is one of three very abundant species of gregarious sea ducks that winter at coastal locations in the North Pacific and migrate into the Beaufort Sea from mid-May to mid-June. They nest on the Arctic tundra and rear their young on tundra lakes and ponds. Males leave their tundra nesting areas and conduct a relatively short molt migration to the coastal barrier island-lagoon systems where they concentrate in large flocks of flightless individuals during the period of 15 July to 15 August. Females and young-of-the-year individuals remain on the tundra lakes and ponds until freeze-up during late September to early October. By late October most oldsquaw have departed the Beaufort Sea for their winter quarters at coastal locations in the North Pacific."

"The effects of low-level aircraft over and near concentrations of molting sea-ducks have been documented. Low-level (150 m) aircraft overflights elicit a stronger response from the flightless sea ducks than do higher level overflights."

Recommendations

Biology and Bioacoustics--Birds

"Preliminary controlled experiments are needed on the common eider, lesser snow goose, and oldsquaw ducks to separate the effects of man-made acoustic and visual stimuli. Use eiders within the Beaufort lease area for experiments and controls. Snow geese at Howe Island are in a sensitive position, conduct experiments in Canada, e.g., Anderson River Delta. Experiments with oldsquaw should be more detailed. Needed are data on long-term effects from displacement and dispersal on all impacted birds. Determine hearing capacities and sound production capabilities."

"Avoid flying aircraft over eider nesting areas from 20 May to 15 July at altitudes less than 500 m (or at altitudes for the specific aircraft that will result in sufficiently low sound pressure levels on the ground), especially at Cross, Pole, and Thetis islands. Apply the same mitigation for snow geese at Howe and other islands in the Saganirktok River. Avoid flights over sea ducks in and near the Beaufort lease area from 15 July to 15 August, especially the coastal barrier islands and river deltas."

Executive Summary (Pages v-vi)

"The Acoustical Society of America (ASA) through its Coordinating Committee on Environmental Acoustics (CCEA) was alerted in 1979 to the possibility of an adverse impact of man-made noise on Arctic wildlife. At the request of the Alaska Eskimo Whaling Commission (AEWC), the ASA convened a workshop for the express purpose of taking an inventory of present knowledge on noise sources and their effects on wildlife, assessing the potential hazard of man-made noise associated with proposed Alaska Arctic (North Slope-Outer Continental Shelf) petroleum operations on wildlife and preparing a research plan to secure the knowledge necessary to enable proper assessment of noise impact. The workshop was held February 24-29, 1980, in San Diego, California."

"The evidence submitted at the workshop indicates that existing scientific knowledge is insufficient for a comprehensive scientific appraisal of the impact of man-made noise from projected petroleum-related activity on Arctic marine wildlife. Furthermore, based on reported direct observations and other scientific data, there is a significant likelihood of possible adverse effects on certain marine birds, ringed and bearded seals, and bowhead whales. Some concern was also expressed about other animals, including the gray and beluga whales, walrus, polar bear, spotted seals, fish, and lower animals in the food chain."

"Noise sources which were identified as most likely to produce effects are: seismic pulse generators used during the exploration phase; transportation sources such as helicopters and other aircraft; surface vessels such as tugs, work boats, etc.; and vehicles on land and ice, such as trucks, tractors, snowmobiles, etc. Other possible sources are oil well drilling, island and causeway building, and petroleum and gas production and processing."

"Appraisal of the expected noise impact with any degree of certainty requires much additional data on noise sources, noise propagation in the Arctic environment, general ambient noise conditions, physical environmental factors, and animal response to such noise. These data may be used in an existing source-path-receiver analytical model to estimate potential noise impact boundaries. Evaluation of noise impact boundaries can provide a continuing mechanism for identifying priority research needs. This approach, combined with carefully planned programs of direct observation and monitoring of animal behavior in the critical areas may be expected to provide reasonably good noise impact estimates when the necessary data for the analytical model become available."

"A scientific research plan is presented, with priority indicators, to provide the needed data. It is estimated that under this plan, preliminary estimates of potential noise impact should be forthcoming in one to two years, and that definitive estimates should come in about five years. A rough approximation of the cost of this plan is thirty million dollars over a period of five years. Effective prosecution of this research plan should involve major cooperative efforts by government, academic, private, and industrial activities."

"Various avenues are identified for utilization of the acoustic impact assessments and other technical outputs of the research program for guiding industrial development in the Alaska Outer Continental Shelf areas."

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Anderson, D. W., and J. O. Keith. 1980. The human influence on seabird nesting success: conservation implications. *Biological Conservation* 18:65-80.

Authors' Abstract

Based on studies of brown pelicans *Pelecanus occidentalis californicus* and Heermann's gulls *Larus heermanni*, disturbances by recreationists, educational groups, local fishermen and scientists alike can be seriously disruptive and damaging to breeding seabirds in the Gulf of California and off the west coast of Baja California. Similar instances have been identified throughout the world--the problem is not difficult to document, but it is difficult to eliminate. The increasing human-seabird contacts on islands in the Gulf of California and along the west coast of Baja California raise serious questions and immediate concern about the continued preservation of nesting colonies of marine birds in those areas. Conservation measures must consider the extreme sensitivity of many seabirds to the inter- and intraspecific behavioural imbalances created by human disturbances. In some cases, total exclusion of humans may be required; in others, limited access might be possible under closely managed conditions at certain times of the year. A symbiotic relationship between seabird conservation, legitimate research and tourism should be the desired goal.

Anderson, J.M. 1978. Protection and management of wading birds. Pages 99-103. In *Wading Birds*. A. Sprunts IV, J.C. Ogden, and S. Winkler (eds.). National Audubon Society, Research Report No. 7. New York, N.Y.

Control of Human Disturbances p. 99-100

"While shooting for food or for lack of anything better to do may not have much impact on the overall population of most species, human disturbance, with or without a gun, can have disastrous results for an individual colony. During the nesting season, the Roseate Spoonbill (*Ajaia ajaja*) is extremely vulnerable to human disturbance. Robert Porter Allen (1942) was convinced that desertion of an entire colony could result from the intrusion of even well-meaning observers or photographers from the time of the flock's arrival at the nesting site until the young are well grown. The National Audubon Society has concluded, however, that this does not mean that spoonbill nesting colonies must forever be shut off from public gaze. We have found that a boat can be anchored approximately 100 m. from a colony and the birds can be observed or photographed satisfactorily with long-range lenses. Much depends on the exact point at which the birds are in the nesting cycle."

"Spoonbills seem unable to renest once they have abandoned the effort; therefore, extra precautions to protect this species during the nesting season are necessary. The degree of protection needed by other species varies tremendously. In 1946, I witnessed the shooting of an estimated 10 percent of a colony of Black-crowned Night Herons. Most of the birds were in the nest-building stage; some were laying. Shotguns were used about sundown by a group of five men who hoped to force the colony to move away from their commercial fishing grounds. Despite the noise and mortality that occurred, the colony had resumed normal activity the next morning and went on to complete a successful nesting season. About ten years later, the heronry was abandoned for reasons known only to the herons."

"At Port Clinton, Ohio, on the Winous Point Marsh, Great Blue Herons (*Ardea herodias*) built a heronry beside a service road which a pickup truck used regularly. The birds always flushed as the truck passed, milled about in the sky, and settled again. This colony, established about 1950, is still active."

"Similarly, Great Egrets (*Casmerodius albus*) and Snowy Egrets (*Egretta thula*) are much more tolerant of human disturbance than are Roseate Spoonbills. The same is apparently true of other native herons and egrets. Nevertheless, at the present time we cannot safely make broad generalizations regarding the amount and type of human disturbance various wading birds will tolerate, except for the Roseate Spoonbill. It may well be that each heronry is unique in this regard. For example, ground-nesting Great Blue Herons, in contrast to tree nesters, are extremely disturbed by humans wading in nearby waters."

"Along the Texas Coast, wading bird colonies have developed on several spoil islands as well as natural islands. Several islands for which we have records have been continuously occupied for more than 50 years. Pearson (1921) reported thriving colonies on Green Island, Second Chain of Islands, South Bird Island, and North Bird Island. These and at least six others became National Audubon sanctuaries, and still are".

"In Texas all navigable waters are considered public. Therefore, the U.S. Fish and Wildlife Service cannot prevent increasing numbers of airboats from displacing some Whooping Cranes (*Grus americana*) from their winter territory on Aransas National Wildlife Refuge. The State of Texas apparently has the authority to keep the boats away but so far has not exercised it (D.R. Blankinship, pers. comm.)."

"Reserach in progress by R.T. Paul (pers. comm.) has already shown that human disturbance is a major cause of nesting failures of Reddish Egrets (*Dichromanassa rufescens*) and several other species of herons, Black Skimmers (*Rynchops nigra*), and terns. All fish-eating bird colonies are within a 45-minute to one-hour boat run from any of several public launching ramps. Sport fishing is the dominant human activity in the bays of Texas. Unfortunately, some of the largest heronries, such as on the Second Chain of Islands, are located on islands which are the most popular fishing spots."

Management

"In addition to protecting the birds themselves from human disturbance, much can be done to preserve, restore or improve their habitat. Coastal waders obviously are heavily dependent on islands, probably because the islands are adjacent to aquatic food and the surrounding waters provide a deterrent to human and four-footed predators.

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- Pearson, T.G. 1921. Notes on the bird-lit. of Southeastern Texas. Auk 38:513-523.

Austin, O.L., Jr., W.B. Robertson, Jr., and G.E. Woolfenden. 1972. Mass hatching failure in Dry Tortugas Sooty Terns (Sterna fuscata). Proceedings International Ornithological Congress XV:627. The Hague, The Netherlands, E.J. Brill, Leiden. (Abstract only.).

"The Dry Tortugas colony of Sooty Terns Sterna fuscata and Brown Noddies Anous stolidus has enjoyed a phenomenal annual breeding success for more than half a century, thanks largely to protection first by the National Audubon Society, then by the National Park Service. In 1969 the birds returned in their usual numbers (ca. 50,000 pairs of Sooties, 2,500 of Noddies) in early April, laid their eggs, and started incubating normally. When we arrived to band the young in mid-June, instead of the usual hordes of Sooty chicks, we found almost none. About half the normal number of adults were still present, and markedly wild and restless. Apparently only a few of the earliest-laid eggs had hatched, a very few were still being incubated, and the rest were deserted, most containing dead, partly-grown embryos. We were able to band only 242 Sooty chicks instead of our normal 20-25,000. The Noddies, on the other hand, hatched normally and their production of young was highly successful."

"What made the Sooty Tern eggs fail halfway through incubation is still somewhat uncertain. We were able to rule out most of the possible causes: there had been no weather abnormalities, no shortage of food in the neighboring waters, no disturbance by natural predators or human visitors to the island. Laboratory examination of eggs, chicks, and adult tissues for pesticides showed them to contain the "typically low residues of animals feeding on relatively uncontaminated food". The only unusual elements we could discover were first an overgrowth of the island vegetation, which made it difficult for the Sooties to reach their nests in the more populous sectors, and secondly frequent sonic booms by jet planes breaking the sound barrier. The latter were almost a daily occurrence, and some were strong enough to shatter windows on adjoining Garden Key. To the occasional sonic booms of previous seasons the birds reacted by rising immediately in a "panic flight", circling over the island momentarily, and then usually settling down on their eggs again. We have no evidence that sonic booms caused physical damage to the eggs, but it is entirely possible that strong booms occurred often enough to disturb the Sooties' incubating rhythm and cause desertion. Action has been taken to curb planes breaking the sound barrier within range of the Tortugas, and much of the excess vegetation has been cleared. At the time of writing (21 May 1970) the birds are having a good season and hatching is proceeding normally."

Batten, L. A., 1977. Sailing on reservoirs and its effect on water birds. *Biological Conservation* 11:49-58.

Author's Abstract

There is increasing pressure to develop many existing water spaces in Britain for recreational activities. This trend will increase disturbances to water bird populations. This paper considers these problems and suggests the sorts of information which are needed for formulating multi-purpose amenity plans for water spaces, where a conservation interest exists. The study at the Brent Reservoir in north-west London has shown that a few species of waterfowl, e.g. Anas platyrhynchos, Aythya fuligula, Aythya ferina, still use the reservoir in autumn and winter despite an intensification of sailing activities. This use and the successful breeding of Podiceps cristatus and other species of water birds depends on the existence of a large enough part of the reservoir which is shallow and marshy and not accessible to boats. As there is some suggestion that larger flocks are more sensitive to disturbance than smaller ones, refuges may be made more effective by proper screening.

Minimum distances ducks tolerate

"There is some suggestion that the larger the flock the more sensitive they are to approach, but more observations are needed to test this properly. Small groups of smew were generally less sensitive and allowed approach to within 100 m before taking to the wing. Mallard behaved similarly to smew. It has been noted that teal, wigeon and shoveler are more sensitive than mallard, but no minimum distances are yet established."

Barry, T. W., and R. Spencer. 1972. Wildlife response to oil well drilling. CWS unpublished report, Edmonton, Alberta. 39 pp. March 1972.

Rig Activities

"Other aspects of drilling, including 'tripping' in and out of the hole and changing bits, are not as noisy as 'casing'. Routine rig activities are relatively noisy, ranging from 82 decibels in the doghouse (a control room adjacent to the rig) to 104 decibels when tripping (Smith 1971)."

"An important part of a drilling operation is a drill stem test, in which hydrocarbons in the formation being tested are forced to the surface and into a pipe from the hole to the flare pit. When the first pressure started, muddy water poured from the line into the flare pit. Next, accompanied by hissing noises, gas condensate was bled out of the line into the flare pit and ignited. The ignition was followed by rumblings which subsided as the line was closed off to allow pressure to build again."

"Drilling ceased in mid-August. Additional tests (standard seismic velocity survey) included detonation of charges of dynamite, ranging from 85 to 135 pounds, dropped into holes drilled into the ground at distances of about 150 yards from the rig. Each blast resulted in disturbance of the tundra with frozen soil thrown from the shot holes."

Discussion and Conclusions

"The results of statistical analyses of data collected on the study plots, and qualitative data obtained, indicate that only 43% of the wildlife appears affected by human activities associated with well-drilling. Molting flocks and family groups of whistling swans, white-fronted geese, Canada geese, and snow geese avoided the rig area in 1971 most consistently. White-fronted geese in usual numbers could not be accounted for in the general vicinity. Pintails, green-winged teal and scaups (also species of economic importance) were affected by the Taglu operation. The raven, as expected, was attracted to the rig area. The occurrence of whimbrels more frequently in the rig area than away from it can possibly be accounted for by a pair having nested at the same spot in seasons prior to the presence of the oil rig. The 1971 nest, approximately 250 yards from the rig and under the helicopter route, was not successful."

"One cannot generalize from limited observations in one season about the effects of Taglu well drilling operations on wildlife. Some species are apparently not affected during drilling and associated activities while others are. Of the affected species, some react more radically than others. The reduction in white-fronted goose population in the general vicinity from 2,300 in 1970 to 475 in 1971 was not accounted for, but the whistling swan population shifted a few miles away."

"As our observations during helicopter activity suggest, effects of rig activity on wildlife are also indirect, as when gulls and gaegers take eggs while geese and other birds are frightened from their nests. The

more subtle effects of noise levels, camp and rig sanitation, camp movements, boat operations, changes in terrain, were not studied quantitatively."

"More specifically designed studies must be made and hopefully this report provides some indication of that need. Wildlife population studies on the Taglu rig site in 1972 would indicate the permanency of any effects. Similarly, it might be found that, should the site be abandoned, an island of gravel might artificially enhance the nesting habitat for some species, as the stacks of pallets did for snow buntings (Figure 24)."

"A more thorough investigation of a helicopter route or an air corridor to and from the rig might prove to be one of the most successful means of minimizing disturbance of nesting waterfowl. It is commonly observed by field biologists that for some reason wildlife is more easily disturbed by helicopters than fixed-wing aircraft, and that, in the course of our field trials, it was evident that the higher the aircraft was above ground the less the disturbance. Altitudes of 500 feet seemed a satisfactory height for minimum disturbance on most occasions, but that should be verified."

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- Smith, L. K. 1971. Noise Problems in the Oil and Gas Industry in Alberta
Division of Industrial Health Service. Albert Dept. of Health.
Speech at Industrial Health Association Conference, Toronto, 12 pp.

Bart, J. 1977. Impact of human visitations on avian nesting success. *The Living Bird* 16: 187-192.

Methods

"The hypothesis that visiting nests increases the risk of predation for a short time following the visit was investigated by estimating the daily mortality rate (DMR) for several days after the nests were visited. Equal DMR's for each of the first several days after the visit indicates that the mortality rate was not affected by the visit; a high DMR on the first day after the nests were visited, and lower DMR's thereafter, indicates that the visit increased the mortality rate."

"Two types of daily mortality rate were calculated: total nest mortality--loss of the entire clutch or brood; and partial nest mortality--loss of some, but not all, of the eggs and nestlings. Since those predators that are likely to follow an observer to the nest (e.g., skunks and raccoons) usually destroy the entire clutch or brood, I expected that visits would not affect the partial nest mortality rate but would cause some increase in the total mortality rate."

Results and Discussion

"As expected, the partial mortality rate was not affected by visiting the nests of any of the species during the incubation or nestling periods. In contrast, the total mortality rate was higher on the first day after a visit than on subsequent days during the laying, incubation, and nestling periods. During the laying period, there was a clear impact of visiting on four of the five species. Barn Swallows were the exception, probably because their nests are usually inaccessible to predators. The effect of a visit during the incubation period could be determined only for the robin and bluebird. Nests of both species were more likely to fail the day after a visit than on subsequent days. Visits during the nestling period had the same deleterious impact on Mourning Doves. There were insufficient data to test for effects on nestlings of other species. The average increase in mortality (excluding Barn Swallows) was nearly three-fold, eight percent or more the day after the nests were visited and three percent or less on subsequent days."

"It is instructive to determine how much error can be caused by observer-induced predation in the calculation of nesting success. In Table 4, nesting success has been calculated twice, first by using the normal Mayfield (1975) method, which does not take account of observer-induced predation, and then by using a modification of Mayfield's method (see Appendix 1) that corrects for observer-induced predation. The analysis shows that the error in the estimate of nesting success may be surprisingly large and that it depends on the interval between visits. If the interval between visits is only four days, then the estimate of nesting success may be less than half the true success rate (the rate at unvisited nests). The error decreases with increasing time between visits

but even if the interval is eight days, the estimated nesting success is still only about 75 percent of the true rate."

Appendix

"Correction of Mayfield's method to exclude the effect of induced predation. In Table 4, Mayfield's (1975) method was used to calculate nesting success, assuming that the partial nest daily survival rate was .98 for all days and the whole nest daily survival rate was .90 the first day after a visit and .98 on subsequent days. These values are approximate averages of the data in Table 1 to 3. The effect of visiting the nest was to decrease daily survival from .98 to .90, so to remove this effect survival was recalculated assuming that both partial and whole nest survival rates were .98 per day. The corrected nesting success rate, assuming a nesting attempt length of 28 days, was therefore $(.98 \times .98)^{28} = .32$."

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- Mayfield, H. F. 1975. Suggestions for calculating nest success.
Wilson Bull., 87: 456-466.

- Beaver, R.D., and V. Lewin. 1981. Scheduling censuses of breeding White Pelicans (*Pelecanus erythrorhynchos*) in northern Alberta. Canadian Field-Naturalist 95(2):198-201.

Introduction

"Determination of the number of nests by visits on the ground can cause abandonment of the site by the pelicans (Farley 1919; Carson 1966; Sanderson 1966; Vermeer 1969; Johnson and Sloan 1976), and the practice should be discouraged. Gull predation, and heating, chilling, or trampling of nest contents also may result from activities that force adults to abandon their nests (Johnson and Sloan 1976). Nest censuses should therefore entail minimal disturbance, particularly if subsequent productivity (fledgling) surveys are to be reliably free from the bias introduced by research activities."

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- Farley, F.L. 1919. The White Pelican in Alberta. Canadian Field-Naturalist 33:38-39.
- Johnson, R.F., and N.F. Sloan. 1976. The effects of human disturbance on the White Pelican colony at Chase Lake National Wildlife Refuge, North Dakota. Inland Bird Banding News 48:163-170.
- Sanderson, R.M. 1966. The colonial birds at Suggi Lake, Saskatchewan in 1966. Blue Jay 24:121-123.
- Vermeer, K. 1969. Colonies of Double-crested Cormorants and White Pelicans in Alberta. Canadian Field-Naturalist 83:36-39.

Blokpoel, H. 1981. An attempt to evaluate the impact of cannon-netting in Caspian Tern colonies. J. Colonial Waterbird Group 4:61-67.

Conclusions and Recommendations: Pages 66-67

"After two brief visits to the five colonies, spaced at least five days apart, nest desertion frequencies ranged from 0% to 3% while frequencies of nest-contents reduction ranged from 0% to 13%. The short visits, properly timed and carefully executed, apparently did not do major damage to the marked nests. On the other hand, it is reasonable to attribute the minor damage observed largely to those two brief visits. During the first pre-netting visits we noted several tern eggs with fresh peck holes when we were leaving the colonies. When Caspian Terns are disturbed by a human visit, Ring-billed Gulls and Herring Gulls have a chance to destroy the exposed and undefended tern eggs. Under undisturbed conditions this kind of egg destruction rarely takes place (P.M. Fetterolf and H. Blokpoel, unpublished data)."

"After the cannon-netting operations, nest desertion ranged from 3% to 7% and nest-contents reduction from 11% to 22% on four of the five colonies (Table 1, 4). On the fifth colony, Halfmoon Island, the frequencies of nest desertion and nest-contents reduction were much higher (30% and 46%, respectively): a shortage of food for the chicks may have been a contributing factor. Except for Halfmoon Island, it seems reasonable to consider the increased levels of damage observed after the netting operations as being largely the result of those activities because they provided the gulls with many chances to destroy undefended eggs and chicks."

"In most cases, the netting operations caused little outright desertion of the marked nests. I do not know whether the owners of the deserted nests re-nested later and, if so, whether they remained at the same colonies or relocated elsewhere. Some of the color-marked Caspian Terns that deserted their nests at Hat Island in 1977 after cannon-netting were observed re-nesting later at other colonies in Lake Michigan and a few of the marked deserters re-nested at Hat Island itself (Cuthbert, pers. comm.). Cannon-netting as a method to gather data on immigration and emigration in Caspian Terns (Ludwig, 1974) is suspect as it affects the phenomenon under study in unknown and varying degrees."

The data strongly suggest that visits to Caspian Tern colonies, and especially large-scale operations such as cannon-netting, are detrimental to the well-being of the birds. More definitive studies, involving observations from a blind before, during, and after human activities, are required to confirm these suggestions. Until such studies have been completed, visits and other human activities should be allowed only in special cases where the likely gains would clearly outweigh the likely losses. When colonies are visited, the visits should be brief and the weather should be favorable (no rain, no strong winds, and neither too hot nor too cold). As far as timing of visits is concerned, the best time is when most terns are late into incubation. Unfortunately, because Caspian Terns nest asynchronously (at least in the Great Lakes area), even properly timed visits may cause problems for newly hatched chicks and late nesters."

Literature Cited:

Ludwig, J.P. 1974. Recent changes in the Ring-billed Gull population and biology in the Laurentian Great Lakes. Auk 91:575-594.

Brubeck, M.V., Thompson, B.C. and Slack, R.D. 1981. The effects of trapping, banding, and patagial tagging on the parental behavior of least terns in Texas. J. Colonial Waterbird Group 4:54-60.

Introduction: Page 54

"Subsequent to the first year's field work the United States Fish and Wildlife Service (USFWS) Bird Banding Laboratory received critical comments regarding the efficacy of using patagial tags on Least Terns. In particular, it was suggested that tagging females could cause abnormal parental behavior such that females competed with their chicks for fish brought to the nest by foraging males. Thus, with the concurrence of the Bird Banding Laboratory, we undertook a study of the differential effects of patagial tags and handling procedures on the parental behavior and nest success of Least Terns during the 1980 nesting season."

Summary and Recommendations:

"We studied the effects of trapping, banding, and patagial tagging on the parental behavior of Least Terns in five colonies on the central Texas coast during the 1980 nesting season. Adult Least Terns were captured with nest traps or with cannon-nets at loafing areas. We compared parental behavior and nest outcome among experimental groups that differed from each other in the extent of experimental manipulation. Observations were made at 89 nests."

"Least Terns that were nest-trapped and marked with patagial tags deserted nests at a greater rate than did terns that were handled less extensively. Brooding terns that were nest-trapped and tagged accepted significantly more fish from their foraging mates than did birds that were subjected to lesser degrees of handling. No differences occurred in rate of food delivery to chicks or in chick survival rates among experimental groups or controls. The behavior of terns captured with cannon nets and marked with patagial tags was similar to that for unmarked birds."

"In light of the data collected during this study, we suggest that patagial tags can be used on Least Terns without substantially altering the parental abilities of birds so-equipped. However, as the handling necessary to apply patagial tags in conjunction with trapping at nests enhances desertion rate, we recommend that patagial tags, if used, be applied only to Least Terns captured away from the nest site. Although patagial tags did not appear to alter parental behavior under our experimental conditions, the effects of patagial tags on behavior and survival subsequent to the breeding season remain to be determined."

Buckley, F. and P. Buckley. 1972. The breeding ecology of Royal Terns (Sterna (Thalasseus) maxima maxima). Ibis 114:334-359.

Predators and mortality Page 357

"Laughing Gulls, almost always present at Royal Tern colonies, are the major source of egg mortality. Surprisingly, the terns do not react to the gulls, rarely even lunging at or moving away from one unless it is very close. Although the gulls we were watching were unbanded, individual differences suggested that many different individuals were involved. Gulls also sit with terns, and while it is often hard to delimit a "flock", our sample counts from Fisherman's Island indicate that there are usually small numbers of gulls associated with, and often in the middle of, most flocks of resting terns."

"While the colony was disturbed, the terns would fly up, swirling overhead and calling noisily. If the disturbance was not too severe, the gulls would either be the last to fly up, or would not fly at all, and in any event they usually settled down before the terns and began puncturing tern eggs. Rather than eating each egg as it was punctured, the gulls showed remarkably economical behaviour: one after another, eggs were punctured and then left to ooze yolk, the gulls moving on to more eggs. The terns would not sit on the punctured eggs, and the gulls were then free to come back and consume them at their leisure, uninterrupted by any terns. Frequently, Laughing Gulls would carry eggs away from the nest and eat them, behaviour probably prompted by the presence of other competing gulls."

"For their part, the gulls seemed to ignore the terns, reacting more to aggressive displays by close Laughing Gulls and often stopping egg-puncturing to interact with another gull. The most severe reaction a lunging tern would elicit from a gull intent on egg-puncturing would be a deft side-stepping and a slight change of course; occasionally a tern would actually supplant a gull. But under all conditions, we never heard a gull vocalise at terns."

"Once the chicks had hatched, all direct predation attempts on terns by Laughing Gulls ceased. Unlike their European counterparts, Black-headed Gulls, the Laughing Gulls were never seen taking young chicks, though it would have been easy to do so. They seemed content to follow the creche when it was disturbed, swooping down to snatch up fish the excited chicks usually disgorged or that adults occasionally dropped. Here too, the gulls mixed with the terns attending the creche, and were also ignored."

Bullock, I.D. and C.H. Gomensall. 1981. The breeding populations of terns in Orkney and Shetland in 1980. *Bird Study* 28:187-200.

Colony impermanence Pages 198-199

"The fact that Arctic Terns move unpredictably from site to site between seasons invalidates all but the most comprehensive of regional surveys. Any shift of colonies between seasons does not necessarily reflect a population change; it may simply be a response to an unpredictable food source, for example. Nevertheless, wholesale colony movements in mid-season must represent some breeding failure. The biological factors responsible for these desertions have been inadequately studied. Morris and Hunter (1976) adduce loss of suitable habitat, human disturbance, predation, toxic chemicals and competition from gulls as factors affecting Common Terns in Canada."

"There appears to be no shortage of suitable nesting habitat in Orkney and Shetland. The preferred habitats of shingle beaches, holms and rough, low coastal pasture all abound, and many apparently suitable sites remain unused. Regarding the future, major developments planned for Shetland and Orkney are confined to oil terminals and associated residential areas. So far both are away from the main tern nesting areas. Further improvement of pasture may affect colonies elsewhere; the indications are that improved pasture carries fewer nesting terns. Human disturbance is certainly a cause of some desertions, but the overall distribution of tern colonies is away from areas of human settlement and intensive crofting."

Literature Cited

Morris, R.D. and R.A. Hunter. 1976. Factors influencing desertion of colony sites by Common Terns (*Sterna hirundo*). *Canad. Field-Nat.* 90: 137-143.

Bunnell, F.L., Dunbar, D., Koza, L. and Ryder, G. 1981. Effects of disturbance on the productivity and numbers of white pelicans in British Columbia - observation and models. J. Colonial Waterbird Group 4:2-11.

Introduction: Page 2

"Only one breeding colony of White Pelicans (*Pelecanus erythrorhynchos*) exists in British Columbia. The colony nests at Stum Lake (52°24'N, 123°3'W) which was designated a Provincial Park in 1971 to protect the pelicans."

"During the eight years for which we have detailed records the major factors contributing to the decline of the pelican appeared to be disturbance by humans (low flying aircraft) and coyote predation. Both factors can dramatically reduce survivorship of young and overall productivity of the colony. This paper discusses those factors and examines their potential impact over longer periods by using a simple simulation model."

Results and Discussion: Page 8-10

"Results of the simulation runs are summarized in Figures 2 and 3. Those figures indicate what would happen if the empirical effects of disturbance on clutch size and survivorship that we documented for specific years were to occur at selected frequencies. The frequencies selected ranged from 1 to 5 times per 20 years. An undisturbed population at Stum Lake would slowly increase about 1% per year (Table 3). Disturbance by low-flying aircraft after incubation (late) had little effect on population growth (Fig. 2B). Although the survivorship of young per egg was reduced by 5% (Table 3), those young were exposed to 3 years of substantial mortality before entering the breeding population. Using the mortality regime incorporated (Table 3), the fledged young experienced 59.2% mortality over the three years prior to breeding, which minimized the effects of small changes in mortality over the first few months of life. Late disturbance by aircraft apparently could occur as often as once every two years before population growth became negative. At that frequency of disturbance, population growth over the 20 year period would be about 0.6% annually, and 129 eggs would be laid in the 20th year (recall that the initial number of eggs was 100). Disturbance by aircraft during incubation had more pronounced effects. (Fig. 2A). Data available suggest that any such disturbance more frequently than once per 20 years would enforce a decline in the population (Table 3). If at a frequency of once every four years the population would decline from 304 birds to 192."

"Despite the omissions the model seems broadly accurate in predicting rates of undisturbed population growth and the observed rate of decline when long-term means are employed. The sensitivity of our conclusions to estimates of adult mortality can be evaluated easily. We noted that early aircraft disturbance and late coyote disturbance were the most detrimental, producing declines in the population of 2.3% and 3% respectively if occurring five times within 20 years (Table 3). If an 'adult' survivorship of 85% is used (2.5% higher than that in previous simulations), then computed rates of change under those disturbances are altered (0.5% growth and -0.1% decline respectively). For disturbances occurring four times every 20 years the differences are similar; 1.1% growth versus 1.6% decline

for early aircraft disturbance and 0.6% growth versus 2.2% decline for coyote predation. Two important points emerge: 1) a small change in adult survivorship significantly alters predicted rates of change in population numbers, and 2) the adult survivorship employed (82.5%) is likely realistic (simulations using 85% do not match documented declines)."

"Given the predicted rates of population change (Table 3) and the frequency of disturbances (Table 1), several management actions can be evaluated. Human induced disturbance was more frequent than coyote-related disturbance (Table 1). Aircraft disturbance early in the breeding period was much more damaging than that occurring later (Fig. 2). Enforcement of legal overflight altitudes concentrated early in the breeding season would be most effective. Conversely, coyote depredation was more damaging when it occurred after incubation. During years of little winter and spring precipitation that would induce lower water levels and increase accessibility by coyotes, it would be advantageous to assign temporary wardens to the Park. Given the White Pelican's apparent sensitivity to coyote predation and its present status as endangered in British Columbia, some such action appears essential during conditions encouraging coyote depredation."

Burger, J. 1981. The effect of human activity on birds at a coastal bay. *Biological Conservation* 21:231-241.

Author's Abstract

I examined the direct and indirect effects of human activity on birds at a coastal bay refuge along the Atlantic Coast. Over the year, human activity varied at different sample sites on the refuge, but people were present on part of the refuge every day, although activity was concentrated on designated paths around a freshwater pond and at a fishing pier. On the refuge (exclusive of the ponds) people were present at the sample sites 17% of the time, birds were present 42% of the time when people were present, but birds were present 72% of the time when people were absent. Human activities, such as jogging or grass mowing, which involved rapid movement or close proximity to roosting birds, usually caused them to flush. Slow-walking bird watchers and clammers did not usually cause birds to flush. Gulls and terns were least affected as they usually relanded where they had been, ducks usually flushed and flew to the centre of the pond, and herons, egrets and shorebirds were most disturbed and flushed to distant marshes. These results suggest that if management objectives include providing roosting areas for migrating shorebirds then some areas must be protected from close and fast-moving human activities.

Introduction P. 232

"Although it is well known that human activities disrupt or disturb birds there are few quantitative data on the nature, frequency, or duration of that disturbance. Recently several authors have examined the effect of human disturbance on breeding birds, particularly those that nest colonially (but see Bart, 1978). These are particularly vulnerable because large numbers are concentrated in one location, and eggs and chicks are vulnerable to predation, cannibalism and the environment (cold, heat, rain, etc.) when parents are disturbed. In 1972, Hunt (1972) noted that human disturbance influenced reproductive success in herring gulls (*Larus argentatus*) and subsequently, several authors have shown effects of human disturbances on other species of nesting gulls. Gillett *et al.* (1975) found that human presence on a nesting island of glaucous-winged gulls *L. glaucescens* did not increase egg mortality, but did increase chick mortality. Nonetheless the overall chick mortality was low (8-13%) compared with other undisturbed colonies (Gillett *et al.*, 1975). Robert & Ralph (1975) found that the presence of the investigator influenced breeding success in western gulls *L. occidentalis*, although the relationship was not entirely linear. Hatching failure was directly proportional to the amount of disturbance. They attributed this discrepancy to the tendency for frequently disturbed chicks to be unafraid of humans, whereas chicks infrequently disturbed were more frightened of humans and ran into adjacent territories where they were attacked by conspecifics."

"Double-crested cormorants *Phalacrocorax auritus* are also vulnerable to human interference (Kury & Gochfeld, 1975; Ellison & Cleary, 1978). Frequent disturbance causes nest abandonment and gull predation, and discourages later nesting pairs from settling (Ellison & Cleary, 1978). Similarly, gull predation can significantly affect shag *P. albiventer* reproduction in colonies disturbed by humans. Human visits to black-crowned

night heron *Nycticorax nycticorax* colonies caused nest abandonment, predation of eggs, and mortality of young (Tremblay & Ellison, 1979). Moreover, frequent disturbance also discouraged late-nesting pairs from breeding."

Methods P. 233

"Responses included no disturbance (birds remained where they were) or disturbed (birds flew). Disturbed birds either landed where they had been or flew to another location (either on land or water). Aircraft were continually landing or taking off from Kennedy Airport at the rate of one every two or three minutes. Thus, it wasn't feasible to record the effect of every aircraft on birds. However, whenever a plane did disturb birds, the species present, their response, and the type of aircraft were recorded. Presumably the disturbance from aircraft related to noise levels, although the supersonic transport (SST) produces considerable structural vibrations as well (Wesler, 1975, 1978). The relative effect of the SST could be judged because it is easily identifiable, whereas the many kinds of subsonic jets are less easily distinguished."

Discussion P. 238 & 239

"People on horse back do not seem to provide a threat even though they frequently moved rapidly. Birds flushed only when it was necessary to avoid being trampled. In this case, birds seem to be placing the person and horse into a horse category, rather than into a person category (see Herrnstein, 1976)."

"Species differences in avian responses were also clear. Gulls and terns were least disturbed and more often returned to where they had been, ducks responded to disturbance by relocating on the nearby pond or bay, and herons, egrets and shorebirds flushed and flew to distant marsh areas. These differences suggest different strategies for dealing with disturbance, but all reflect flying to safer roosting areas. Presumably gulls, terns and ducks have learned that the water is safe from humans as they often flew there at a disturbance, but returned to the beach when the people had passed. Shorebirds did not do this as frequently, instead they completely left the area. This difference may reflect habituation since gulls and terns are present all year and shorebirds are only migrants on the refuge."

"Avian response to aircraft require comment. In this study birds generally did not respond to subsonic jets, but they always responded to the supersonic transport whenever it passed directly overhead. The SST had landed at Kennedy for several months prior to the start of this study. Nonetheless, individual birds might be expected to have limited exposure since many were migrants. The SST is a louder aircraft than subsonic jets as dBA levels of the SST averaged 108 ± 3.8 and ranged as high as 116 (J. Burger, Unpublished data). Furthermore, SSTs also produce sonic booms and noise-induced structural vibrations (Wiggins, 1974, White, 1975, Wesler, 1975, 1978). The results of this study clearly indicate that birds respond to the SST noise by flushing although many returned to where they had been. Thus birds were still visible a few minutes after an SST had taken off or landed. This observation has prompted researchers to note that gulls are unaffected by aircraft noise (see Busnel, 1978). That gulls may remain near an airport even with the sound of the SST does not prove that they are undisturbed by the noise. Birds may remain near

an airport because, on balance, it provides the safest foraging and loafing areas, or indeed the only foraging or loafing areas. Certainly, in the case of Jamaica Bay Refuge, the advantages of the refuge outweigh the disadvantages of the airport noise or the other human disturbances."

"The results of this study have clear management implications. Disturbance to gulls and terns is generally transitory, and the birds return when the disturbance is passed. Ducks and brant are intermediate in response in that they may land nearby, but usually do not immediately return. Shorebirds, however, are vulnerable in that they frequently vacate the area when disturbed. This suggests that when shorebirds are using a particular area (as they do the ponds during high tide), human activity should be restricted to a distance from their loafing areas."

Literature Cited

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Burger, J. 1981. Effects of human disturbance on colonial species particularly gulls. J. Colonial Waterbird Group 4:28-36.

Introduction: Page 28

"Colonial birds are particularly vulnerable to human disturbance because of the large concentrations of birds nesting in close proximity. Vulnerability varies depending on species, nest location, and the type of disturbance (see Manuwal 1978). Nearness to human activities is one key factor, as the potential for disturbance is much greater regardless of a species' intrinsic vulnerability. Mere distance is not sufficient to assess the potential for disturbance because the surrounding habitat affects human (or predator) access. Birds nesting a half mile from a town on an island surrounded by deep, rough waters are surely less vulnerable than those surrounded by solid ground. Similarly, nesting habitat is crucial: nests on cliffs are less accessible than are nests on flat ground, nests in trees are less accessible than are ground nests, and burrows are less accessible than are surface-areas. Ground-nesting species such as gulls, terns, and some herons, egrets, ibises, and cormorants are thus particularly vulnerable to human disturbance because they are accessible and often nest in close proximity to human activities."

"The types of human activity that affect colonial bird populations are varied, ranging from overall destruction to direct intervention such as entering colonies, collecting eggs, and killing adults, eggs, or chicks. The response of colonial birds to human activities varies markedly, but no species can withstand the direct effects of killing adults, eggs, or chicks for sustained periods of time. Assessing the effects of human disturbance on nesting colonial birds is a difficult task because the observer can never completely remove himself. The problem is further complicated by the decreased accuracy of success measurements with fewer egg or chick censuses. Observation of reproductive success from afar is usually impossible in the egg stage, and is complicated in the chick phase by the presence of vegetation and rocky or uneven terrain."

"Reproductive success can be lowered either directly by causing desertion of nests, eggs or young, by adults, or indirectly by causing thermal stress, predation, and cannibalism."

General Discussion: Page 34. Extensive Review Pages 33-34.

"As is apparent from the above discussion, the effects of human disturbances are many and varied. With several years of data on the effects of human disturbance I find that reproductive success is sometimes higher and sometimes lower in completely undisturbed study areas. Although it is easy to demonstrate behavioral differences in attentiveness, aggression rates, and chick mobility, the relationship between these events and reproductive success is less clear, and varies among species. Clearly, the investigator must evaluate how each procedure affects the behavior and reproductive success of the birds he is examining."

Summary: Page 34

"People affect nesting colonies of birds in diverse ways. They can destroy

the nests, eggs, or chicks or force birds to abandon their nest sites and colonies. They can keep adults off their chicks and eggs, thus exposing them to temperature stress or predation. The above effects can be lethal to eggs or chicks, and result in immediate and obvious decreases in reproductive success. Many other effects of human disturbance are less obvious, but nonetheless contribute to lowered overall breeding success. Such effects include; decreased incubation and chick attendance, shifts in the mate incubating, earlier and distant movements of chicks, entanglement of chicks in vegetation, increased brood sizes (when several chicks enter the same nest), more frequent aggressive encounters, greater energy expenditures for territorial defense, and attraction of predators to nest sites."

Literature Cited:

Manuwal, D.A. 1978. Effect of man on marine birds: a review. Pages 140-160. In Wildlife and People. Purdue Univ. Press, West Lafayette, Indiana.

Cairns, D. 1980. Nesting density, habitat structure and human disturbance as factors in Black Guillemot reproduction. Wilson Bulletin 92(3):352-361.

Methods

"I found nests through repeated ground searches. I checked nests every 1-5 days on Brandypot, and daily (in the heavily disturbed zone) or every 4 days (in the lightly disturbed zone) on St. Mary's. In assessing the effect of my visits I considered a "visit" to be whenever I passed within 15 m of a nest."

Results

"Overall nesting success was highest in the St. Mary's lightly disturbed area where 0.97 young per nest fledged (Table 2). This value was not significantly different from the success rate on Brandypot (0.64 chicks fledged per nest), but was significantly higher than the 0.38 young produced per nest in the St. Mary's heavily disturbed zone. Most of the difference between production rates in the St. Mary's heavily vs. lightly disturbed areas was due to lowered hatching success in the heavily disturbed area; differences between the 2 areas were large and significant for eggs hatched per nest and eggs hatched per egg laid, but the difference between rate of chicks fledging per chick hatched was small and not significant (Table 2)."

"The relation between breeding success and observer disturbance on Brandypot was examined with a Kendall rank-order correlation between the number of nest visits and a ranked scale of breeding success. The scale assigned values of from 1-6 according to success achieved (i.e. 1 or 2 eggs laid, 1 or 2 eggs hatched, 1 or 2 chicks fledged). The Kendall coefficient was non-significant ($t = -0.08, P > 0.05$)."

Discussion

"Reproductive success of Black Guillemots nesting in the part of the St. Mary's colony subjected to daily visits was much lower than in the part visited once every 4 days. Unfortunately, the possibility that observer disturbance might have a detrimental impact on breeding success was not suspected during planning of the fieldwork, and the 2 St. Mary's study areas are not strictly comparable, as the nesting density in the heavily disturbed zone is much higher than in the lightly disturbed zone (Table 1)."

"Despite the depression in success rates associated with observer interference, maximum weights attained by fledglings were considerably higher in the St. Mary's heavily disturbed area than in the lightly disturbed area. Those birds which succeeded in hatching their eggs in the face of daily disturbance may have been more attentive or more experienced as parents than the average successful nester in the lightly disturbed area. Robert and Ralph (1975) found a similar situation in a colony of Western Gulls (*Larus occidentalis*), where hatching success dropped with increasing disturbance, but chick survivorship rose."

"Previous studies of the effects of human interference on seabird reproduction indicate that disturbance lowers breeding success by raising the susceptibility of eggs or young to intra- or interspecific predation (Johnson 1938, Hunt 1972, Gillet et al. 1975, Ellison and Cleary 1978). The directly harmful effects on parental care induced by human interference have been documented poorly in colonial seabirds, although the possibility of such effects has been suggested by several authors, including Bergman (1971) for Black Guillemots, and Nettleship (1975) for Gannets (*Morus bassanus*)."

Summary

"Breeding success, breeding synchrony and condition of young at fledging were measured in 2 Black Guillemot colonies. Nest productivity was lower, but maximum chick weights were higher, in an area disturbed daily than in an area disturbed once every 4 days."

Literature Cited

- Bergman, G. 1971. Gryllteisten *Cephus grylle* in einem Randgebiet: Nahrung, Brutresultat, Tagesrhythmus und Ansiedlung. Commentat. Biol. Soc. Sci. Fenn. 42:1-26.
- Ellison, L.N., and L. Cleary. 1978. Effects of human disturbance on breeding of Double-crested Cormorants. Auk 95:510-517.
- Gillett, W.H., J.L. Hayward, and J.F. Stout. 1975. Effects of human activity on egg and chick mortality in a Glaucous-winged Gull colony. Condor 77:492-495.
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- Johnson, R.A. 1938. Predation of gulls in murre colonies. Wilson Bull. 50:161-170.
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- Robert, H.C., and C.J. Ralph. 1975. Effects of human disturbance on the breeding success of gulls. Condor 77:495-499.

Campbell, L. H., and H. Milne. 1977. Goldeneye feeding close to sewer outfalls in winter. Wildfowl 28:81-85.

Reaction to Disturbance (pg 82)

"The birds were obviously sensitive to sudden loud noises. On eleven occasions when such occurred (for example, blasting or ship sirens) they immediately took flight and left the bay. On six days no birds had returned after two hours and less than 10% of the original flock returned on the remaining five, which merely swam further offshore. However, from the west passers-by tended to come into view suddenly, close to the sewer and the birds usually took flight.

The occurrence of passers-by was highest between 08.00 and 09.00 and from 13.00-16.00 (Figure 6). These peaks of human activity coincided with the peaks when Goldeneye presence was highest and the diurnal distribution pattern of the birds was not therefore a response to disturbance.

The time taken for the first bird to return to the sewer area following disturbance was recorded on 28 occasions (Table 1), and was significantly longer during the middle of the day. (Range 2-9 min. at 08.00-11.00 h; 3-22 min. at 11.00-14.00 h; and 3-7 min. at 14.00-17.00h.)"

Choate, J.S. 1967. Factors influencing nesting success of eiders in Penobscot Bay, Maine. J. Wildl. Manage. 31: 769-777.

Author's Abstract:

Histories were recorded for 1,030 American eider (*Somateria mollissima dresseri*) nests on five islands during two breeding seasons in Penobscot Bay, Maine. Nesting success was 39 percent in 1964 and 36 percent in 1965. Predation by gulls was responsible for most nest losses. Five factors were found to be related to nesting success: nesting cover, clutch size, partial predation, gull population, and human disturbance. Nests in hardwood shrubs and cow parsnip (*Heracleum maximum*) had relatively high success while those in grasses and nightshade (*Solanum dulcamara*) were much less successful. Nests with a complete clutch of fewer than four eggs were less successful than those with four or more eggs. When part of a clutch was lost to predators the chance of ultimate success of the remaining eggs was reduced. The number of nesting gulls per nesting eider on a given island was inversely related to the nesting success of the eiders on that island. Human disturbance was indirectly responsible for lowered nesting success.

Methods

"Commencing in the early spring of both seasons, visits were made at least once a week to each island to search for eider nests, except when adverse weather prevented. Searches were limited to a maximum of 3 hours in an attempt to prevent overexposure of eggs to adverse temperatures when unattended by females."

"This procedure was altered somewhat in 1965 to test the effect of human disturbance on nesting success. Goose Island and East Goose Rock, which had about the same success and same number of visits in 1964, were checked an unequal number of times in 1965. Goose Island was visited 27 times spaced throughout the season and East Goose Rock 12 times. On the basis of 1964 data, I assume that if there had been no human disturbance in 1965 nesting success would have been about equal on the two islands."

Human Disturbance

"In many waterfowl production studies human influence is a factor, although its importance is often hard to measure. In the present study, human disturbance appeared to influence nesting success to a great extent. Observations from a blind showed that after an investigator left an island, the gulls returned much sooner than the eiders. Of course, before the eiders returned, the nests were highly vulnerable to predation by the gulls."

"Observations during a nest-trapping and banding operation on Robinson Rock, in 1965 also indicated the effect of human disturbance. When the island was revisited one or more times on the same day, after setting nets or banding eiders, many newly destroyed nests were evident. Gulls were seen flying back to the island as soon as the workers left, and they no doubt

destroyed many nests before the eiders returned. Grenquist (1959) also believed that flushing a female eider from her nest gave crows a chance to destroy the nest. Black-backed gulls were observed by Todd (1963) to break up an eider nest after a man flushed the female."

"Human disturbance did not appear to cause much nest desertion. Only a small percentage of nests was considered deserted (Table 1) and it is not known how many of these were actually the result of human disturbance. It should be pointed out that nests could have been abandoned and subsequently destroyed before they were labeled deserted. Thus, the actual percentage of abandoned nests could have been somewhat higher than shown in Table 1."

"There is disagreement as to the effect of human disturbance on nest desertion. Paludan (1962), who captured breeding female eiders on the nest and banded them, noted that few abandoned. Usually the females returned to the nests in a short time. However, Hilden (1964) studied several species of ducks and observed that the eider was the species most apt to desert its nest. In a number of cases the nest was abandoned after the female was flushed only once."

"A few clutches apparently were lost because of overexposure to heat when nests were checked on hot, sunny days. Several cases of partially developed embryos were suspected to be the result of this exposure. Overheating occurred when many eiders were flushed from their nests and it was 2 hours or more before the observer could cover all the eggs."

"During artificial incubation of eider eggs, a temperature of 42 C or higher may kill all the embryos (Rolnik 1943: 157). This temperature was occasionally exceeded in the present study. Overheating occurred primarily in sparse cover where the eggs were not sufficiently shaded from the direct sunlight. There was no evidence that any losses were caused by excessive cooling of the eggs."

"As with desertion, losses to overexposure may have been greater than indicated in Table 1. Embryos could have died and the eggs have been eaten by predators before it was known that the embryos had perished. In such cases the nests would have been included in the predation category."

"As mentioned in Methods, there was differential human disturbance on two islands in 1965. Goose Island, with more than twice as many visits, had 27 percent nest success - about two-thirds that for East Goose Rock (40 percent). Chi-square showed the difference to be significant ($P < 0.10$). Thus, with greater human disturbance on Goose Island, nesting success was significantly lower."

"In the Cape Dorset Area, Northwest Territories, egg loss was heavier than normal when the eiders were frequently disturbed (Cooch 1966). Paynter (1951) believed that an observer's presence contributed to decreased eider nesting success."

"Milne (1963) attempted to measure the effect of disturbance on success in a manner similar to that of the present study. A study area that was visited daily was compared with a relatively undisturbed control area. Although success was somewhat lower (3 percent) in the disturbed area, the difference was not significant."

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Christenson, B.L. 1981. (unpublished) Reproductive status of common loons in areas of high and low recreational activity in Maine. Maine Co-operative Wildlife Research Unit Annual Report. May 1980 to April, 1981. Pages 33-34.

Unpublished Authors Abstract: (M. A. Thesis)

"Common loon (*Gavia immer*) reproductive ecology and response to disturbance were studied in Maine during 1979 and 1980 in 2 areas of Maine with differing levels of recreational use."

"Overall reproductive success, in terms of chicks fledged per territorial pair, was similar to rates observed in studies elsewhere. Nesting success was higher than recorded for common loons by other researchers, but chick survival was much lower."

"Loons in an area with a high level of recreational use showed high tolerance to boating disturbance during nesting. This tolerance resulted in successful nesting despite the disturbance. Loons in an area with a low level of recreational use did not show this tolerance of disturbance. Loon broods move greater distances ($p < 0.05$) when boats are present but the energetic cost of this added movement and its impact on chick survival are unknown."

Cooke, A. S. 1980. Observations on how close certain passerine species will tolerate an approaching human in rural and suburban areas. *Biological Conservation* 18:85-88.

Author's Abstract:

Information was obtained on how close passerines tolerate an approaching human before flying away. Species tended to be significantly more approachable in suburban areas than in rural areas. There was also a significant association between degree of tolerance and size, with small birds, such as tits (Paridae), allowing a closer approach than larger species, such as corvids.

Introduction

The need to determine the direct impact of man's activities on birds has been emphasized in a series of recent publications (Hume, 1976; Batten, 1977; Cooke, 1977; Liddle & Scorgie, 1980). Some effort has been made to establish how close wildfowl on reservoirs will tolerate boats, with attention being paid to the reactions of different species to craft of different types (Hume, 1976; Batton, 1977). In this paper, an attempt is described to determine how near passerine species allow an approaching observer before flying away.

Discussion

The simple method used in this survey allows an assessment to be made of the relative tolerance of a species under certain conditions. This technique could be extended to determine the effect of variables, such as season, age, flock size or weather conditions. Similar methods should prove valuable in continuing the much needed evaluation of the impact of man on birds and other wildlife.

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DesGranges, J.-L. and A. Reed. 1981. Disturbance and control of selected colonies of Double-crested Cormorants in Quebec. J. Colonial Waterbird Group 4:12-19.

Discussion: Page 18

"Our data confirm those of other investigators and indicate that disturbance results in increased losses of eggs and chicks. However, those losses do not necessarily lead to the production of substantially fewer chicks; eggs and chicks that survive the disturbance may fare better in the absence of their nest mates, lost clutches may be replaced, or "new" adults may move in to take the place of those that have deserted the colony (Duffy 1979, Ellison 1979). Disturbance-induced losses at Ile aux Pommes and elsewhere in the estuary clearly did not cause population decline. It is possible that recruitment of home-bred birds to Ile aux Pommes was deficient, but if so the deficit was compensated for by recruitment from other less disturbed areas. It is yet too soon to judge the impact of the egg and chick destruction from 1978-80 on total nesting population levels because the young birds from those cohorts have not yet reached breeding age. It seems unlikely, however, that drastic declines will be recorded on Ile aux Pommes in coming years because the large, less-disturbed colonies nearby probably produced young in sufficient quantities to fill any vacancies created by localized controls."

Summary: Page 18

"Double-crested Cormorants (*Phalacrocorax auritus*), nesting in mixed colonies with gulls (*Larus spp.*) in the St. Lawrence estuary were subjected to various levels of disturbance and population control. On 26 June 1978, the Ile aux Pommes colony was disturbed four times by investigators. These visits resulted in the loss of 37% of the eggs and 13% of the young (N = 25 nests). Nests near the periphery of subcolonies and those containing only eggs suffered most from predation by gulls. The proximity of a gull nest or perch did not seem to increase the risks of predation."

"During the last quarter century, two attempts at reducing the colony of cormorants on Ile aux Pommes failed. In 1954-55 and 1978-80, most eggs and young cormorants were destroyed. Almost every year since 1963, biological surveys were conducted on the island, inevitably causing disturbance. Despite those disturbances the number of pairs nesting on Ile aux Pommes has more than doubled (2.5x) since 1963, a rate of increase greater than that of the entire population of the St. Lawrence estuary (1.7x). In recent years, the colonies of Double-crested Cormorants on Ile Rasade du Sud Ouest and in the Ilot le Pilier de Bois were submitted to partial and regular controls. These attempts failed, as indicated by population increases at both sides."

"We conclude that population control could only be achieved by extensive, sustained, and massive destruction of nests and their contents."

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Donihee, J. and P.A. Gray 1982. A review of road related wildlife problems and the Environmental Management Process in the north. Department of Renewable Resources, Government of Northwest Territories. Info. Rep. No. 2. Yellowknife. 20 pp.

Author's Abstract

"Road development potentially can cause significant direct and indirect impacts on wildlife and wildlife habitat. To avoid or minimize detrimental effects associated with road development, wildlife resource concerns must be incorporated during the initial planning stages of development. Three classes of impact reduction measures exist. Spatial measures seek to avoid areas of environmental importance, while timing measures eliminate disturbance during critical periods of the life-cycle. Operational measures embrace codes of good practice that serve to reduce the overall effects during each development phase. Ignoring or failing to undertake comprehensive environmental programs can result in expensive delays and design changes".

RECOMMENDATIONS Pages 15 - 16

Our brief review of literature on the road development process and the effects on wildlife has identified two major problems.

(1) Road Planning

The road development process must include environmental information from the beginning. A lead time of up to 2-3 years may be necessary to complete wildlife studies. A coordinated interdisciplinary approach is required to identify information gaps, establish information gathering priorities, and ensure communication among the project specialists.

We must eliminate the concept of environmental assessment as a one-time predictor of impacts. Environmental assessment should be an ongoing and iterative process, eventually merging with management. This concept is a central component of Holling's (1980) call for adaptive environmental assessment and management.

Environmental reviews have not been, for historical reasons, a part of road planning in the N.W.T. Serious discussion among responsible agencies must occur and careful efforts should be directed at ensuring that new roads are planned to minimize losses of renewable resources.

(2) Status of Wildlife Information and Techniques

The comprehensive reviews referred to earlier identify several common problems with respect to a wildlife manager's ability to contribute to the environmental assessment of roads. Methods are not comparable between many of the existing studies. Gaps in the data base on wildlife species abundance, distribution, and the location of critical wildlife habitat exist for many areas studied.

There is a need for selective studies to accompany road development from concept to operation, maintenance, and abandonment. We say selective because what we need to learn or to begin to study are the long-term effects of roads on wildlife. The root of this problem then, is the lack of techniques that enable wildlife biologists to develop statistically reliable, quantitative measures of behavioural and physiological reactions to linear disturbance, and the effects of these factors on wildlife populations.

These problems can and must be dealt with as soon as possible. The GNWT-WS, in cooperation with the Canadian Wildlife Service and Alaskan biologists, has begun basic research designed to develop techniques to measure behavioural impacts. These techniques will enable studies of the effects of disturbance due to roads on wildlife populations. When combined with careful environmental assessment, mitigation and regulation of access, we hope to enhance the compatibility of northern road developments with wildlife resources.

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Ellisson, L. N., and L. Cleary. 1978. Effects of human disturbance on breeding of double-crested cormorants. *Auk*, 95:510-517.

Authors' Abstract

In 1975 and 1976, studies of the Double-crested Cormorant were conducted in the St. Lawrence Estuary to assess the influence of investigators visiting colonies during the breeding season. Frequent visits caused nest abandonment, gull predation, and discouraged late-nesting birds from settling in disturbed experimental colonies. Late clutch commencement was more prevalent in the relatively undisturbed controls. Birds were less susceptible to disturbance in the second year of study, but for some reason other than habituation.

Introduction

"Human disturbance has been reported to increase predation by gulls and crows on eggs and young Double-crested Cormorants (Mendall 1936, Drent et al. 1964, Vermeer 1970, Lock and Ross 1973, Kury and Gochfeld 1975). Nestlings may also die of prolonged exposure to heat or cold (Mendall 1936). Controlled studies of human interference have been conducted on several species of gulls (Kadlec and Drury 1968, Hunt 1972, Robert and Ralph 1975, Gillett et al. 1975), all of which noted some adverse affects."

Results (p. 515)

"Cormorants made no attempt to expel from the colony gulls or crows in the act of predation. During the undisturbed periods one or two gulls often roamed unmolested among the nests searching for bits of fish. One pair of gulls that nested in the colony seemed responsible for most of the egg predation, but these and other gulls were extremely aggressive toward crows that entered the colony. Thus we agree with several other authors who suggest that the presence of gulls who repel raiding crows can augment hatching success in colonial birds (Olsson 1951, Koskimies 1957, Reed 1973, Dvernychuk and Boag 1972)."

Discussion

"Kury and Gochfeld (1975) have recommended that colonies managed for tourists should be visited late in the nesting cycle when young are half grown. We agree with this recommendation because nest abandonment is most likely to occur early in the season. Kury and Gochfeld also suggested that some disturbance early in the season would be desirable so as to induce loss of nests, subsequent re-laying, and thus the presence of late nests with eggs and young for viewing later in the season. We do not concur with the latter. On Gros Pâlerin our disturbance early in the season did not have this effect, the late nests being found mostly in the control sites."

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Man-associated Mortality Factors - P. 110

"Directly or indirectly, man appears to have been chiefly responsible for the jeopardized status of all threatened wildlife species in the United States. Our use of the term "mortality" in the following discussion refers not only to the loss of individuals but also to the decline of the species. It is treated under 3 categories: human disturbance, habitat modification, and hunting and specimen collecting."

Human Disturbance. -- "The whooping crane is by nature extremely wary and does not remain long near human activity. Most captives remain aloof and merely tolerate man's presence to the extent that their captivity requires. The same trait applies in the wild, apparently accounting in part for the remoteness of nesting areas, wintering grounds, and migration stopover points. However, human disturbance is tolerated when it is of short duration and does not involve obvious danger. On the wintering grounds, the birds show little concern for the tourist boat "Whooping Crane," which ferries visitors along the Intracoastal Canal for observation and photography."

"Both whooping cranes and sandhill cranes are distrustful of aircraft, particularly helicopters, and seem especially fearful of attack from above. However, during the years that whooping crane eggs have been gathered from wild nests in Canada, the breeding pairs have exhibited a declining concern for approaching aircraft. They seem to have learned that there is little to fear, and consequently return to the nest soon after the human visitors have departed."

"We can only surmise the extent to which settlement of the midcontinental prairies and mere human presence, as opposed to habitat alteration, may have interfered with continued use of agricultural land by breeding whooping cranes. These large, conspicuous birds could not have remained long in any settled area without drawing the attention of someone who would wish to reduce them to objects of closer inspection or even meat for the table. One or 2 attempts to do so should have alerted the survivors to the dangers of man's presence."

Breeding Grounds Research and Management - P. 112

"Fire patrol and suppression, periodic censusing, prohibition of public access into and low-flying aircraft over the nesting area, and prevention of economic exploitation of the area by various commercial interests remain the 4 most important management functions performed in Wood Buffalo National Park each year. Obviously, little control can be exerted over the weather, predation, water levels, or vegetation growth, and consequently nesting success is governed primarily by the inherent conditions of the breeding pairs and the environment. Most active management is directed toward benefiting the bison, for which the park is named."

Erwin, R. M. 1980. Breeding habitat use by colonially nesting waterbirds in two mid-Atlantic U.S. regions under different regimes of human disturbance. *Biological Conservation* 18:39-51.

Author's Abstract

More than 80% of the beach-nesting seabirds (common tern, least tern, black skimmer, and herring gull) in coastal Virginia nest on natural barrier island beaches, while in New Jersey the vast majority nest on dredge deposition material or natural marsh islands. This contrast probably results from the differences in human disturbance in the two regions. Although 75% of all oceanfront in New Jersey allows unrestricted recreation, about 85% of the Virginia beaches are "protected" under the ownership of several conservation agencies. Attendant with changes in habitat utilisation in New Jersey, competitive interactions have apparently intensified with herring gulls usurping tern and laughing gull nest sites. Other implications are discussed.

Fitch, M.A. and Shugart, G.W. 1981. Minimizing investigator disturbance in observational studies of colonial birds: Field tests of an above ground tunnel system. J. Colonial Waterbird Group 4:68.

Author's Abstract:

"Entering and exiting observation blinds placed within nesting colonies causes disturbance. Effects associated with disturbance bias data collected from blinds. To minimize unwanted disturbance and bias, we have designed and used an above ground tunnel that permits undisturbed access to observation blinds. The tunnel consists of individual sections of plastic film attached to a wooden and steel frame."

"Major investigator influences we have eliminated in Caspian Tern (Sterna caspia) observational studies include: abandonment of scrapes during pre-laying, loss of chicks, and long distance movement of broods from their natal sites. In Herring Gull (Larus argentatus) colonies, the use of tunnels has eliminated chick mortality that occurred when disturbance created by entering and exiting blinds displaced the young from their territories."

"Minimizing investigator disturbance may not be necessary or feasible in all studies. However, questions which attempt to assess interindividual differences in reproductive behavior as related to fitness are best answered with detailed observations on marked individuals. Generalizations made from these data are more realistic when observer bias is eliminated. (Wilson Bull., in press.)"

Fetterolf, D.M. 1981. Reproductive success of minimally disturbed Ring-billed gulls. J. Colonial Waterbird Group 4:68.

Author's Abstract:

"Reproductive success (Numbers of fledglings/pair) of Ring-billed Gulls (Larus delawarensis) was monitored in three breeding seasons. Gulls were observed from a blind or a remote viewing station. Investigator disturbance during incubation ranged from one visit in 1980 (15 min) to nest checks every second day (3-12 min) in 1977-78. After pipping began, visitation ceased or was rare (once just after the onset of hatching). Reproductive success ranged from 2.10 to 2.53 and was compared to similar measures of fitness from other investigations of the species. Minimally disturbed success was found to be at least 60.4% higher than the average from previous studies. Possible causes for the large differences are discussed."

Fetterolf, P.M. 1983. Effects of investigator activity on Ring-billed Gull behavior and reproductive performance. *Wilson Bull.* 95(1):23-41

Introduction P. 23

Human disturbance can be a detriment to hatching success in Herring Gulls (*Larus argentatus*) (Hunt 1972) and Western Gulls (*L. occidentalis*) (Robert and Ralph 1975). The activities of scientists can also cause significant reductions in fledging success (Glaucous-winged Gull [*L. glaucescens*]) (Gillett et al. 1975). These studies and others (Emlen 1956, Timbergen 1960, Ashmole 1963, Harris 1964, Kadlec et al. 1969, Anderson and Keith 1980) have reported the behavior of chicks in response to human intrusion but none has quantified the observed behavior of adults and chicks. In this study I; (1) quantify human disturbance effects on Ring-billed Gull (*L. delawarensis*) adult and chick behavior, as well as reproductive performance; (2) compare past findings on reproductive performance to data I collected at two different colonies in four different years; and (3) examine the theoretical ramifications of biased reproductive performance resulting from human activity.

Summary P. 39-40

I documented the effects of human disturbance on gull (*Larus* sp.) behavior and reproductive performance in two different colonies between 1976 and 1980 by observing gull behavior and reproductive performance during periods with different levels of investigator activity. Human disturbance precipitated changes in gull behavior which caused significant reductions in fledging success, fledglings per nest, and net reproductive output even when disturbance was limited. In contrast, areas which were relatively undisturbed during the post-hatching period in 3 years and two colonies had very few chick deaths. Human disturbance caused adoptions and enhanced seasonal patterns of chick mortality. I conclude that human-induced chick losses could have had confounding effects in most past studies involving larid reproductive success and may seriously confound theoretical interpretations of reproductive strategies in terrestrial-nesting colonial birds.

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Fyfe, R. W., and R. R. Olendorff. 1976. Minimizing the dangers of nesting studies to raptors and other sensitive species. Can. Wildl. Occas. Paper No. 23. Ottawa 17pp.

Authors Abstract

This paper discusses the problems resulting from human interference with the nests of sensitive bird species. It notes the toll of eggs and nestlings caused by an undiscerning general public, which makes it especially necessary for amateur bird-watchers and professional biologists to act responsibly when they visit active nests. One set of problems centres on the desertion of nests by frightened adult birds, the injury to eggs and young that they may cause in doing so, the adverse environment for eggs and nestlings brought about by this desertion, and the consequent threats to the feeding and safety of the young. A further set of problems arises from mishandling--the unnecessary handling, awkward handling, admiring, and photographing of young birds in the nest. The discussion includes possible solutions to the problems, and also calls for knowledgeable trespass on a birds territory--or no trespass at all.

Introduction

"Eggs and nestling birds are observed, counted, collected, weighed, measured, and photographed--both casually and professionally--sometimes at the expense of the birds. Because an undiscerning general public continues to take its toll, amateur bird-watchers and professional biologists especially need to act responsibly, and to encourage others to do so, in visiting active bird nests. There must be both compassion and common sense, including the realization that the eggs and young birds that may be jeopardized are the future breeding stock.

It must also be recognized that our current knowledge of nesting birds has come from competent field study. Except for a very few historical instances, this bird research has not had long-term detrimental effects on the population dynamics of any species. This paper is presented in an effort to perpetuate the good record of professional ornithologists and to alert casual bird watchers to potential problems.

Although much of the following may seem superfluous to active ornithologists and naturalists, we sincerely hope that professionals will benefit from the introspection stimulated by the ideas presented, that inexperienced field biologists will profit from the discussions, and that all other bird enthusiasts and casual observers will be encouraged to recognize the problems and develop the empathy necessary to deal considerately with birds in the field.

Our call is for knowledgeable trespass on a bird's territory, or none at all."

Scope of the Discussion

"The authors have used their experiences with raptorial birds (birds of prey) to illustrate problems that may arise during ornithological field studies with bird species that are sensitive to human interference. In addition, we have included the observations and recommendations of other raptor researchers. Of necessity, much of the discussion and general

conclusions follow from specific, often one-time or unusual occurrences in the field. The generalizations that we have made are in the interest of conservational field research.

Any of the following problems could be encountered when a nest is visited:

- 1) the parent birds may become so disturbed that they desert their eggs or young completely; 2) the incidence of egg breakage or trampling of young by parent birds may be increased, as may the chances of cooling, overheating, loss of humidity, and avian predation of eggs; 3) newly hatched birds may be chilled or overheated, and may die in the absence of brooding; 4) older nestlings may leave the nest prematurely, damaging still-growing feathers and breaking bones at the end of futile first flights, or may be forced to spend one night or several on the ground where they may be highly vulnerable to predation; 5) mammalian predators may follow human scent trails directly to the eggs or young; 6) the attention of other people may be attracted by the visitor's activities; 7) mishandling a nestling may damage feathers, bones, and claws; and 8) on cliffs, the visitor may inadvertently knock rocks and other debris onto eggs or young birds."

Gillett, W. H., J. L. Hayward, Jr., and J. F. Stout. 1975. Effects of human activity on egg and chick mortality in a Glaucous-winged Gull colony. *Cordon* 77: 492-495.

Introduction

"The effect of our activity on egg and chick mortality has been of considerable interest to us and the refuge management. It is well known how chicks scatter in response to disturbance with the territory (Paynter 1949, Emlen 1956, Harris 1964, Kadlec et al. 1969). As the result of such displacement, chicks often enter other territories and are attacked by the owners of these adjacent territories. Young chicks are unable to retaliate and may be killed before they can return to their own territories."

"Our research activities on the island necessitated entry into the territories resulting in chick displacement. This paper describes studies undertaken during 1972 and 1973 to determine the extent of our effects on egg and chick mortality and our influence on the full population."

Results and Discussion

"Harris (1964) reported that, with human disturbance, egg stealing was common with Herring Gulls. We did not see stealing or damage of eggs or nest material for the Glaucous-winged Gull on Colville Island. Our observations indicated that Glaucous-winged Gulls settle more rapidly than Herring Gulls following disturbance. Thus, defense of eggs by territory owners is probably greater in Glaucous-winged Gulls. It is interesting to note that egg mortalities in Herring Gulls range from 9-30% (Paynter 1949, Kadlec and Drury 1969). In the Glaucous-winged Gull we observed 7.2% egg mortality in control areas. As eggs that do not hatch or are damaged are not usually removed by the birds our technique of measuring egg mortality seems valid. The fact that a greater egg mortality was encountered in the control areas where counts were made only twice, than in the experimental areas where weekly counts were made, substantiates our conclusion that egg mortality was not underestimated by the techniques used. Thus our conclusion that human disturbance did not affect egg mortality is supported by these data."

"Death of young chicks was most frequently caused by neighboring gulls. Chicks one week old have little defense against adult harassment and death was usually rapid. A number of chicks were also observed to be partly or completely eaten though cannibalism was uncommon. However, cannibalism has been observed frequently in the Herring Gull (Tinbergen 1959). Death also resulted from other causes. Parasites were seen in a number of individuals although death by parasitism is not thought to be very widespread. On a number of occasions a Bald Eagle (*Haliaeetus leucocephalus*) flew over the island and was chased away by adult gulls. On one occasion we observed an eagle flying from the island with a chick in its talons. Judging by the amount of harassment eagles received, we think that predation

by these birds is not significant. A number of Northwestern Crows (*Corvus caurinus*) were also seen on the island and may prey on the nests. Weather was also responsible for mortality in some young chicks on hot days. The continued absence of the adults from a nest was responsible for chicks not receiving enough shade. This had a lethal effect on small chicks."

Summary

"In summary, our presence on Colville Island increased chick mortality in areas where we worked. However, our presence had no effect on egg mortality. There is no overall population decline on Colville. Instead the population is on the increase. Compared with other gull colonies the mortality is small. The observed chick mortality on Colville is near the range of chick mortality (8-13%) on totally undisturbed colonies in the same area. Fifty-five percent of the mortality occurred during the first week after hatching. The increase in mortality resulted largely from chicks moving into adjacent territories and being attacked by neighboring adults as the result of our entering the chicks' home territory."

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B. Synchronizing and Desynchronizing Factors

"In view of the important role that human disturbance plays in seabird colonies, factors that increase disturbance, such as holidays, may have an important effect. Humans not only damage seabirds directly, but facilitate predation (e.g., Kury and Gochfeld, 1975) and mortality (Gochfeld, 1973) indirectly. I have found that Least Terns, which lay early, may fledge their young prior to the 4th of July weekend, which brings hordes of beachgoers into their colonies. Later young may be captured or inadvertently chased far from their parents."

Literature Cited

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Gochfeld, M. 1981. Differences in behavioral responses of young Common Terns and Black Skimmers to intrusion and handling. J. Colonial Waterbird Group 4:47-53.

Introduction: Page 47

"Seabirds that nest in dense aggregations or colonies are susceptible to severe disruption by human activities ranging from total habitat destruction (residential, commercial, or recreational development) and vandalism (destruction of adults, chicks, eggs, or nests) at one extreme to casual intrusion on the other. Recreational development may leave habitats intact but assures frequent interaction between birds and people. Vandalism still takes an occasional toll, although with extensive legal protection the devastation of the past century is seldom seen today. More frequently picnickers, bird watchers, and photographers remain close to the nesting birds providing an unintentional, yet often significant, chronic disturbance. Bird banding activities may pose intense stress, as teams of banders move systematically through a colony deliverately searching for every young bird. All such disturbances must be recognized and reckoned with (Buckley and Buckley 1976). Recently, biologists have recognized the potential impact of their activities on their study animal (see Burger 1981). Disturbance may expose vulnerable eggs and young to predation, attacks by neighboring adults, and to inclement weather (Austin 1929, Ashmole 1963, Gochfeld 1976, Manuwal 1978, Veen 1977). Intense mobbing of intruders by adults may detract from other aspects of parental care (Emlen et al. 1966; Burger and Gochfeld in prep.). In certain species such as Least Tern (*Sterna albifrons*), the young tern may run so far from the nest site as the intruder approaches, that it becomes lost and subsequently perishes (Gochfeld, unpubl. observations)."

"The survival of birds and their reproductive success in areas subject to human disturbance, are influenced by three factors: 1) the type, frequency, duration, and intensity of disturbance; 2) extrinsic conditions under which disturbance occurs; and 3) the behavioral responses of the birds to disturbances. By type of disturbance I mean whether or not one actually touches or handles individual birds. Frequency and duration refer to how often and for how long such disturbance occurs. The intensity refers to the severity of the stress experienced by the birds, the number of nests disturbed, and the amount of confusion that results from each disturbance. Extrinsic conditions include weather and the presence or absence of predators nearby. Behavioral responses include the tolerance of the birds to disturbance and their tendency to adopt either cryptic or escape behavior, characteristics influenced by the species and age of the birds."

Discussion: Page 52

"In summary, four factors influence the behavioral responses of young to disturbances. The first is taxonomic, different species showing characteristic responses under particular conditions. The second is age, older chicks showing different responses than those recently hatched. The third factor is weather, with responses to disturbance on hot, sunny days (air temperature greater than 30°C) differing from responses on cool, cloudy days. The fourth factor is the extent or intensity of handling of chicks. Touching or picking up chicks greatly increases their tendency to run away.

The consequences of forced running and dispersal from the nest site are fourfold:

- 1) chicks may be eaten by predators or conspecifics (=cannibalism).
- 2) chicks may be subject to aggression from neighboring territorial adults.
- 3) chicks may be separated from parents for a period of time sufficient to cause debilitation or starvation, and
- 4) chicks may be exposed to debilitating effects of sun or rain. All four events occur commonly. The first occurs frequently in gull colonies where cannibalism is common, or where predators such as crows have learned to exploit the presence of humans (Kury and Gochfeld 1975). The latter consequences are more likely to affect young chicks that may not be able to return to their natal territory or to identify the calls of their parents (see Beer 1970). For species that nest in tall trees or on cliffs, premature departure from the nest site may be an irreversible and fatal event.

"The size of the colony, its history of disturbance, the timing, synchrony, and density of nesting birds, all will influence responses to intrusion and handling. I have discussed the phenomena associated with disturbance of Common Tern and Black Skimmer young at two colonies on Long Island, but suggest that quantitative differences in these behaviors might be expected at other colony sites."

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Hard, J. L. 1980. Human disturbance in Western Gull *Larus occidentalis* *livens* colonies and possible amplification by intraspecific predation. *Biological Conservation* 18:59-63.

Author's Abstract

Indirect evidence is presented that human disturbances are having a profound effect on reproductive efforts of *Larus occidentalis livens* at several colonies in the Gulf of California. Breeding adults that lose their eggs or chicks apparently practise conspecific predation whether or not humans are present, thus increasing effects of human intrusions. These combined effects could lead to a severe decline in numbers or even pose a threat to the survival of this endemic population, if human disturbance is widespread. Attempts to assess breeding success throughout the Gulf seem warranted and, if necessary, some action to regulate human contact may be essential.

Hatch, J. J., 1970. Predation and piracy by gulls at a ternery in Maine. Auk 87:244-254.

Effects of human disturbance (pg 250)

"The presence of persons near the ternery is important not only for its possible effects on the particular observations reported here, but also for the longer-term effects of the continual presence of people upon the nesting of the gulls and the terns. In the course of their daily duties the Coast Guard personnel restrict most of their activities to a small part of the island, and their presence there means that the terns and Laughing Gulls nesting nearby are partly habituated to humans which is convenient for observers.

The Laughing Gulls seemed to be affected very little by the presence of people, except when close to their nesting area. They seemed not to take advantage of the disturbance among the terns occasioned by persons moving through or round the ternery, nor were they discouraged by it, for they occasionally chased terns at such times. The large gulls, on the other hand, were much more wary and our presence in the ternery may have altered the pattern of their predatory activities, although not in any very obvious way. The gulls did not fly in to seize chicks, for example, indeed their approach seemed to be inhibited, so the effects of disturbance were unlikely those at other colonies where a great increase in predation is alleged to occur. The observations of the rates of chick predation may be too high if the gulls confined their activities to undisturbed times, but such an error is probably more than compensated by the instances of predation that were not seen for many reasons, including fog and the topography of the island. By similar reasoning, the observed rates of chasing by the Laughing Gulls are minimal for the periods of observation."

Holton, G.R. 1982. Possible effects of human activity on the use of lakes by Trumpeter Swans. Page 7. In the Trumpeter Swan Society Newsletter No. 23. February 1982. H. H. Burgess (ed.). (7th Trumpeter Swan Conference, Victoria, B.C. 19-21 February 1981.)

Author's abstract

Data on Trumpeter Swans (*Olor buccinator*) breeding in the Grande Prairie region of Alberta from 1970 to 1979 were analyzed to determine if human activity near lakes influences the swans' use of the lakes. Brood sizes and pre fledging survival of cygnets were also estimated from the survey data and compared for two categories of lakes with differing exposure to human activities. Results suggest that human activity near small lakes may inhibit breeding pair use of those lakes. No consistent relationships could be established between brood size or cygnet survival and human activities.

Hume, R. A., 1976. Reactions of goldeneyes to boating. *British Birds*. 69:178-179.

Notes

"Repeated observations have shown that Goldeneyes (*Bucephala clangula*) often fly when people on the shore approach closer than 100 or 200 metres, but invariably settle again elsewhere on the water. A single sailing dinghy, however, may be sufficient to cause over 60 Goldeneyes to take flight and most to leave altogether within a few minutes, the remaining birds flying up each time the boat approaches to within 350-400 metres and generally leaving within an hour. A powerboat causes virtually instantaneous flight as soon as it appears on the water, the majority of birds leaving, and, if it traverses the length of the reservoir, all the rest leaving within a few minutes.

On 4th December 1974, 38 Goldeneyes undisturbed 100 meters offshore suddenly took flight together and flew right away out of the area when a powerboat had travelled barely 10 metres out from the jetty (and was still 550 metres from the birds). In the strong wind it was inaudible to me and difficult to see against the sun, but the Goldeneyes had reacted immediately to it, as on many other occasions. There was no sign of any other possible cause of their sudden, simultaneous departure.

Clearly the presence of Goldeneyes at Chasewater depends on the availability of a second, 'refuge' water: flocks have been watched flying out of sight towards Blithfield Reservoir (15 km to the north), but numbers there have been inadequate to account for up to 60 displaced birds from Chasewater in addition to the regular flock.

Goldeneye are particularly sensitive and fly up each time sailing dinghies approach to within 300-400 m. Once the birds flew at 700 m when a power boat emerged. On another occasion they allowed approach to within 550 m."

Hunt, G. L., Jr. 1972. Influence of Food Distribution and Human Disturbance on the Reproductive Success of Herring Gulls. *Ecology* 53: 1051-1060.

Author's Abstract

A three year study of Herring Gull (*Larus argentatus*) reproductive success on four islands in Maine indicated that production of young was controlled by different factors operating on the eggs and chicks. Hatching success was inversely related to the disturbance of colonies by picnickers, which apparently caused the adults to leave their eggs exposed to sufficient solar radiation to addle the eggs. The survival of chicks was lower on islands distant from sources of edible refuse (outer islands) than on islands close to sources of waste (inner islands), regardless of visits by picnickers. The nutrition and growth rates of chicks on inner and outer islands were similar. The attendance of parents on the territories was found to be less on an outer island than on an inner island. It is concluded that differences in parental behavior associated with greater foraging effort were responsible for a higher loss of chicks to predation on the outer islands.

Discussion

"When a colony is disturbed, the adults leave the eggs unprotected. Gull eggs are sensitive to overheating (Drent 1967) and even in the relatively cool Maine spring, incident radiation from the sun is capable of overheating them. Furthermore, the eggs are exposed to predation by other gulls flying in the vicinity."

"Hatching success was greatly affected by disturbance of the colony, while it was unaffected by the distance of the colony from major sources of food. Thus, studies attempting to relate reproductive success of gulls to the availability of food must take into account the effect of disturbance on hatching success."

"The length of absence of a foraging parent appeared to be more important as a factor exposing the chicks to predation than as a factor affecting the nutrition of the young."

"The parent gulls must provide not only sufficient food, but also adequate protection for their young, both from bad weather (Vermeer 1963, Harris 1964, Harris and Plumb 1965) and from predation. There is a trade-off between the amount of time adults remain at the colony guarding their chicks and the time they spend foraging (see Perrins, cited in Brown 1967). The time difference between the average lengths of absence of parent gulls on Little Green and Goose Rock was about one hour (Table 8), which approximates the commuting time expected of a gull flying at 40 km per hour (Pennycuik, 1969) over the additional distance that gulls from Little Green must cover to reach mainland food sources."

"Predation in the colonies I studied appeared to be an important source of chick mortality. Although a few very small chicks were found dead in or next to their nests, indicating a failure of their parents to make proper behavioral adjustments, many chicks disappeared without a trace after a few days of growth and are presumed to have been eaten by adult gulls in the colony (see also Harris 1964, Brown 1967, Kadlec et al. 1969). These findings agree with those of Paynter (1949), Fordham (1964), Kadlec and Drury (1968), and Parsons (1971). During this period of maximum vulnerability the presence of only one parent guarding the small chicks left broods on Little Green Island more exposed to predation than if two parents had been present."

"Although I have only once observed a successful attempt at cannibalism, on many occasions I have observed chicks attacked by other gulls. Vermeer (1963), Harris (1964), Brown (1967) and Parsons (1971) have all concluded that predation and cannibalism are major causes of chick mortality. Lack (1968) has suggested that the inshore feeding seabirds will have many small colonies so as to minimize the distance between nest site and feeding area. The mechanism whereby this becomes important is clear from the results of this study. However, it is less clear why the Herring Gulls remain colonial when island nest sites are plentiful and the only predators of consequence appear to be the gulls in the colony."

"If predation and the lack of parental care were the proximate cause of the differential mortality between colonies on inner and outer islands, then the availability of food must be seen as the ultimate cause of this difference in chick survival. When the parents have to spend large amounts of time seeking food, their ability to provide protection to their young is reduced."

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Jarvis, M. J. F., and D. L. Cram. 1971. Bird Island; Lamberts Bay, South Africa: An attempt at conservation. *Biological Conservation* 3 (4):269-272.

Authors' Abstract

Visitors formerly constituted a threat to the breeding success of bird populations on Bird Island, Lamberts Bay. Their activity also reduced the numbers of transient birds roosting on the island. Thus, guano production was depressed. Conservation measures were therefore implemented to protect breeding birds and to avoid disturbance to the nightly arrival of transients, while allowing human visitors to view nests at close quarters. The measures resulted in a vast increase in the non-breeding transient bird population and in the breeding population, as well as an increase in guano production. Adjacent islands showed no increase in guano production; consequently that of Lamberts Bay is attributable to the success of conservation measures.

Introduction

"Bird Island (32°05'S, 18°18'E) was formerly an island off the fishing port of Lamberts Bay (Fig. 1), Cape Province, South Africa, but about 12 years ago it was joined to the mainland by a breakwater which helps to protect the fishing fleet from high seas and also acts as a causeway for the use of harbour maintenance trucks and for pedestrians who wish to reach the Island. This small island, of eight acres (3.2 ha) has two rocky outcrops and a large artificially-paved area from which guano is scraped."

"Numerous palearctic species commonly occur, including large flocks of Common Terns (*Sterna hirundo*), scattered flocks of Sandwich Terns (*S. sandvicensis*), and several species of waders."

"Initially, sea-birds were protected because of the valuable guano they produce. Following a suggestion in the South African Parliament that the culling of birds would increase fish populations, the South African Division of Sea Fisheries commenced research into the diet of sea-birds, to determine their effect on the fishing industry. There was no change in protection regulations following this work. Bird Island, Lamberts Bay, being the only such guano-producing island having easy access from land, has considerable potential as a tourist attraction."

"Following this relaxation of regulations, the numbers of visitors to the Island increased rapidly. Few of the visitors were conscious of the disturbance their movements sometimes produced, and as a result, considerable damage was caused to the breeding populations. Considering the value of guano and the potential value of the birds as a tourist attraction (Jarvis, in press), this could not be allowed to continue. During discussions between the Superintendent of Government Guano Islands, the Harbour Master, and the authors of this paper, it was decided to adopt further conservation measures without delay. These consisted

of closing the Island entirely during peak courtship and nest-building periods, and of restricting visitors to certain small areas of the Island during the late morning and early afternoon in the open season."

Visitors and Their Effects

"In April or May, when most of the breeding activity is finished and the birds have dispersed, guano scrapers collect the season's guano accumulation, but this causes negligible disturbance to the birds. Coasters sometimes offload onto the causeway to the north-east of the Island, and workers and vehicles pass to and fro. But by far the greatest disturbance to the birds has, in the past, been caused by holiday visitors. Sightseers used to walk along the causeway, examining nesting cormorants until they got onto the Island and noticed large concentrations of Cape Cormorants along the sea-defence wall. They left the road to examine these more closely, and then noticed the Gannets in the right background and walked towards them. Frequently, visitors were seen to walk right round the southeastern and northwestern edges of the Gannet colony and between the rocky outcrops. Such sightseeing excursions had various effects on the birds which we will now categorize."

"a. *On Cape Cormorants.* This species has the largest breeding and transient population on the Island (ca 30,000), and is thus very important as a producer of guano. The evening arrival of thousands of Cape Cormorants is a spectacle that attracts tourists. However, the birds are reluctant to roost when people are walking about, and so a large guano contribution is lost. In addition, frequent disturbance to the colony near the road and causeway prevents successful breeding near by. Although adults become more reluctant to leave the nest as the season progresses, they will do so if approached closely enough. Once an individual bird panics, a chain reaction may be set off, until large numbers are charging away from the nesting area. Many eggs are smashed or taken by gulls. Chicks jump from the nest and are often unable to climb back, owing to inaccessibility of the nests or their inability to locate them. These chicks invariably die. The portion of the paved area that is unused by Gannets has been kept free from breeding birds because of frequent disturbance by visitors."

"b. *On White-breasted Cormorants.* These are very timid birds, and they leave the nest with little provocation. Being timid, they are reluctant to return until all signs of danger are past. This enables gulls to take their eggs at leisure, and Cape Cormorants to steal nesting material, without regard for eggs which frequently get dislodged."

"c. *On Crowned and Bank Cormorants.* These two species are probably more fortunate than the others because they nest in more inaccessible places where visitors seldom venture."

"d. *On Jackass Penguins.* Unfortunately, individual guano scrapers have sometimes been seen to destroy nests made under driftwood, and, even though it may only involve a few nests, this is still a significant proportion of the Lamberts Bay breeding stock. The breeding birds

allow cautious visitors to within a few inches before leaving their nests, but even then they quickly return. Consequently, visitors have little adverse effect."

"e. *On Gannets.* The usual approach of visitors is towards the area of the colony where the birds take off. (Gannets often need to run considerable distance before becoming airborne.) Visitors form obstacles, making the birds reluctant to take off. A 'traffic jam' may develop down the edge of the colony and cause considerable bickering. Most important is that the taking-off area borders the growing edge of the colony, where young adults congregate and make their first attempts at courtship and breeding. They are very sensitive, and disturbance can clearly be seen to inhibit their first attempts at courtship. Potential breeders give up if disturbed too often, thus preventing the full natural growth of the colony. Another danger is that four-week-old chicks are more timid than adults, and show a tendency to leave their nests if approached too closely. Such displaced chicks rarely survive, as they are pecked by neighbours as they blunder through the colony."

Conservation Measures

"To prevent any disturbance during the period of high-intensity courtship, nest-building, and egg-laying, the Island is now closed to visitors from September 15 to November 13 (both inclusive). During the open season, visitors are restricted to the hours between 9030 and 1630 each day, because the uninterrupted evening arrival of vast numbers of birds is important for the guano production. No unauthorized vehicles are permitted onto the Island, and so visitors have to approach on foot. In order to prevent disturbance to the Cape Cormorant nesting areas, a rope fence was erected along the full length of the road on both sides, thus restricting visitors' movements to the road area."

Effectiveness of Conservation Measures

"The graph of annual guano production for the past ten years (Fig. 4) shows that, before the additional conservation measures were implemented early in 1968, the annual production was decreasing on three Cape Province Islands, including Lamberts Bay. However, after introduction of these measures, there was a substantial rise in guano production at Lamberts Bay. This was due to more birds breeding and less disturbance to non-breeding roosting birds than in preceding years."

"It is noteworthy that this increased guano production occurred in years when commercial fishing catches showed a further decline in tonnage landed, suggesting that the increased guano yield was not the result of more abundant fish supplies in the coastal waters. It is also significant that the two other neighbouring bird islands of Malagas and Jutten, did not show a significant increase in guano production such as occurred in Lamberts Bay. This increase was made despite the visits of more than 3,000 tourists during the 1968/69 breeding season, and can thus be attributed to the success of the conservation measures."

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Johnson, R. A. 1938. Predation of gulls in murre colonies. Wilson Bull., 50:161-170.

Introduction

"The destruction of large numbers of eggs of the Atlantic Murre (*Uria aalge*) by gulls has been reported by many observers and usually credited to the extreme stupidity of the murre. In eastern North America the Great Black-backed Gull (*Larus marinus*) is the species responsible for the damage and in western waters the Western Gull (*Larus occidentalis*) appears to be the culprit. Methods to check the gull as a predator have been proposed and in some cases introduced without knowledge of the inherent behavior patterns involved in the murre-gull relationship. This procedure may very possibly result in the acceleration of the damage which it is intended to check."

"To better understand the relationship of these birds on the nesting ground let us consider some of their adaptations to food getting and to natural enemies and thus learn in what way their interests clash as neighbours in restricted areas during the nesting season. The gull is normally a scavenger in its feeding habits. It cannot dive for food as can the murre, and is therefore subject to periods of starvation in a way that the murre is not. But the gull is at home in the air, escapes the approaching enemy easily and depends upon its own faculties to recognize safety. The gull is very useful to the murre to warn it of approaching enemies. The warning cry of the gull elicits an immediate response from the murre. As long as man stays out of sight of the nesting murres and the population of the gulls is within reasonable limits, the gull gets for the most part only a scavenger's share of the murre eggs—mostly the abandoned ones. But, if the murre's vigil becomes weakened by any influence, such as disturbance, the former scavenger has little trouble in securing many eggs. Quickly the gull becomes an aggressive predator and takes the first unguarded egg. The adjoining murre missing her accustomed neighbor becomes uneasy and falters at the wrong moment so the gull gets her egg too, and then another and another. Meanwhile the non-incubating group of murres is increasing—a condition which adds to the general restlessness in a way to accelerate the loss of eggs. If the disturbing factor soon desists these unoccupied murres will likely soon produce another egg and incubation pertinacity may be re-established. On the other hand, I found while studying the Atlantic Murre in relationship to the Great Black-backed Gull, that if the colony is accessible to gulls and it is disturbed more than about three times by man during the early incubation period it is likely to be mostly or entirely lost. In cases where the murre colony is relatively small and exposed to gull attack (gulls will not go down into caves or deep crevices), and gull food is otherwise scarce, progressive loss of the murre colony may occur without being in the first place initiated by the disturbance of man. Some of the birds may join another breeding colony elsewhere and lay again."

Field Observation

"... Their great enemy is the Western Gull (*Larus occidentalis*) for the latter is a ruthless pirate and steals and eats the eggs of other birds, especially the Guillemots, at every opportunity. A murre is sometimes attacked by the gulls one on each side, and so harrassed, until one of the gulls gets the egg which he divides with his fellow pirate."

"Keading (1903) gives his observations of the gull damage at the Farallones as follows: 'It is no uncommon sight to see a flock of gulls hovering over a nesting colony of murres in an effort to drive them from their eggs, and seizing every egg that is exposed. Should another cause drive the murres from their eggs, the gulls reap a harvest. This is perhaps as potent a factor as any in the destruction of the murres. For, while the human eggers took only the fresh eggs, they disturbed the whole colony of murres and the gulls took every thing in sight.'"

"In this paper I wish to point out that by the very nature of the murre's responses to fear, the gradual disappearance of that great Farallone breeding population nesting in a location exposed to gull damage was an inevitable consequence of the disturbance by human eggers. They struck the vital blow at this great colony."

"On the north shore of the Gulf of St. Lawrence where I made a study of the Atlantic Murre nesting on the islands where there were Great Black-backed Gulls nesting I could call attention to the following points in their relations: (1) On islands where both species are nesting out in the open, the gulls take a certain percentage of the eggs regardless of disturbance. (2) If the murres are disturbed the damage may be anything up to complete loss of the murre colony. (3) On islands where the two birds are both found nesting, and the murres are protected by being down in crevices, caves, or faults in the rocks, the gulls are not likely to get many of the murre eggs; however, if the murres are disturbed a few times by man they may abandon, even at later dates because of gull cries to which they have become conditioned."

Records and Experiments

"At Wolf Bay in 1931, while studying the birds on Murre Island I discovered that there were about thirty pairs of Great Black-backed Gulls with their territories scattered about among six small nesting groups of murres. All the murre groups were more or less accessible to full attack. One colony was studied almost continuously over a period of several days from a blind placed in a fault in the rock nearby."

"This colony was conditioned to fright because of my appearance when getting into the blind. As the more timid birds delayed the return to their eggs the gull feasted upon these. Thus progressive loss of the colony continued until there were eighty-two eggs remaining. At this time I left the island. When I returned a week later nothing remained but the empty shells of the murre eggs. Apparently the abandonment had been precipitous after a certain point."

Conclusions

1. "The murre normally nesting in colonies on remote islands or inaccessible cliffs, has not evolved a series of responses which permit it to adapt to repeated disturbances in a way to promote the preservation of eggs. The greater degree of adaptation appears to be in its ability to re-form a breeding colony and produce a new crop of eggs."
2. "Breeding colonies of murre which are located in the range with Western Gulls or with Great Black-backed Gulls may be seriously affected either by a pressure from excessive numbers of gulls or from a fear conditioning resulting in gull predation of the eggs or the abandoning of them in locations not accessible to gulls."
3. "This fear reaction is a colony response although it may start in one individual. At first the flight from the breeding site will not occur until the colony has experienced a series of stimuli ending in contact with a predator. After the conditioning the complete series of responses is set off by the warning stimulus."

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Johnson, R.F., and N.F. Sloan. 1976. The effects of human disturbance on the White Pelican colony at Chase Lake National Wildlife Refuge, North Dakota. Inland Bird Banding News 48:163-170.

Introduction

"The effects of human-bird interactions have been studied for many species. There interactions become especially critical during the breeding season and in many cases breeding failure has resulted."

"White pelicans, *Pelecanus erythrorhynchos*, have proven to be extremely intolerant of human activity during the breeding season. Entire colonies may be destroyed as a result of human disturbance (Carson 1966, Mansell 1965, Vermeer 1970)."

"Human interference may also cause disruption in the breeding colonies severe enough to result in an increase in mortality among immature birds. Trampling of young during escape attempts from human intruders has been reported by Kolstoe (1966) and Thompson (1933). Young may also succumb to excessive heat when exposed to the sun for even short periods of time (Marshall and Giles 1953, Hall 1925)."

Results and Discussion

Predation

"Predation is not a problem at Chase Lake in an undisturbed situation. No mammalian predators have been observed on the islands during the breeding season. The primary threat is from California, *Larus californicus* and ring-billed gulls, *Larus delawarensis*, that nest in association with the pelicans."

"During and after any human activity the gulls take advantage of the absence of the adult pelicans and move rapidly into the colonies to attack eggs and very small young. Gulls are more tolerant of human activity than are the pelicans and move freely in the colony while the researcher is present. Regurgitated fish and amphibians were taken in preference to live young with eggs being a second choice. Live young appeared to be least preferred. Kury and Gochfield (1975) observed black-backed, *Larus marinus*, and herring gulls, *Larus argentatus*, utilizing regurgitated fish in preference to eggs or young of double-crested cormorants, *Phalacrocorax auritus*, in Maine."

"If researchers remain in the colony for extended periods predation can become severe. Small colonies may be destroyed while large numbers of peripheral nests in the larger breeding groups are attacked. Numerous authors, including Houston (1962), Marshall and Giles (1953), Schaller (1964) and Low *et al.* (1950) have cited the problems of gull predation in white pelican colonies."

Johnson (1938) observed the complete elimination of common murre, *Uria aalga*, colonies when human disturbance was frequent. Schreiber and Risebrough (1972) reported that fish crows, *Corvus ossifragus*, would attack brown pelican, *Pelecanus occidentalis*, eggs within seconds of the adults departure due to human disturbance."

"Repeated disturbance of breeding pelicans creates the potential for extensive gull predation. During our work at Chase Lake we have found several techniques which dramatically reduce gull predation. During the period that the majority of gulls are incubating the threat of predation is greatly reduced. The gulls are preoccupied with the defence of their own nests and eggs. They do not readily move into pelican colonies that have been disturbed. Nest counts are made at Chase Lake during the Memorial Day weekend (May 26) each year and during the counts predation is virtually nonexistent."

"The number of researchers that enter a colony at any given time should be as small as possible. Ten to fifteen people moving through a pelican colony cause a great deal of disturbance and force large numbers of birds to leave their nests, greatly increasing the risk of predation just before and immediately after hatching."

Physical Stress

"Physical stress, as related to human disturbance, occurred in two main forms at Chase Lake; temperature stress of young and stress caused by trampling and pod movement of older young."

"Naked nestlings may succumb quickly to direct sunlight (Bartholomew and Dawson 1954). Teal (1965) found that during July desertion of white ibis, *Eudocimus alba*, nests with pipping eggs for 30 minutes resulted in the death of the chick under conditions of direct sunlight. At Chase Lake naked young were observed to succumb within five minutes to high temperatures (Table 1)."

"Older young, even though they are more capable of thermoregulation, may also suffer from temperature stress especially during strenuous activity on very hot days (Bartholomew et al. 1953). This factor becomes especially critical when older young are banded on hot days. The crowding together of young and their entanglement in vegetation greatly increases the temperature stress."

"Temperatures at Chase Lake are extreme during the breeding season with readings in excess of 30°C not uncommon. There may also be a wide gradient between air temperature and ground level temperature (Table 1)."

"Trampling of eggs and young as a result of pod movement can also be a severe problem (Behle 1958, Houston 1962, Thompson 1933). Approach by an observer causes the young to flee and in the process, smaller young and eggs may be trampled. Additional injuries include broken wings and dislocated wings and legs."

"Schaller (1964) reported that young normally enter the water at one month of age. However, at Chase Lake one month old young were observed

to enter the water only when disturbed. These young became rapidly waterlogged and chilled. Young would also rest on the mainland after leaving the nesting island increasing the chances of mammalian predation."

"Young may return to a breeding island other than the one on which they had been born. Three banded young were recovered dead on a foreign island. Young that make this mistake will starve since, evidence indicates, adults will not search for their young if they are not on the island of their birth. Teal (1965) reported that disturbance may cause young herons and egrets to leave their nest with the result that they perish because they are unable to find their way back."

"Schreiber and Risebrough (1972) cited numerous factors such as predation, nest loss, temperature stress on eggs and young and the disruption of adult nesting behavior as deleterious effects of human disturbance in brown pelican colonies. They recommend that human visits to brown pelican colonies be curtailed and we agree. We also feel that certain research activities should be prohibited in colonies with fewer than 500 nests. Repeated visits to the nesting area and extended observations should be avoided. Banding activities must be limited or prohibited entirely. Nest counts may be conducted if they are carried out within the guidelines established in this paper. Small colonies may disappear as a result of human disturbance, including research activities."

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Survey Techniques

"Aerial surveying is the fastest, most efficient surveying method. It allows the widest coverage in the shortest possible time for one-shot, replicate work (Buckley and Buckley 1976). For most surveys helicopters are better than fixed-wing craft because of their slower speed and greater maneuverability. Their major drawback is that of disturbance; temporary or permanent nest desertion may occur if helicopters approach too close to some heron and seabird colonies. Fixed-wing aircraft are recommended for large aerial searches. They are efficient for systematic searches flown in transects, and they are useful for following feeding flights to the colony site."

Census Techniques

"In many areas surveying and censusing can be done simultaneously. In addition to surveying bird colonies, fixed-wing aircraft and helicopters are also efficient tools for censusing. For work in such remote areas as Great Blue Heron (*Ardea herodias*) colonies, where nests are located in tall trees, aircraft are almost essential. Aircraft can be used most effectively in colonies where only a few easily distinguishable species are present. The use of helicopters for census work is limited almost exclusively to gull and some seabird colonies where the effect of disturbance is minimal and will not result in large-scale nest desertion. Accurate aerial censuses are best done with a pilot and right and left observers; a fourth person, serving as recorder-photographer, would also be useful."

"Two sampling techniques for estimating the total number of nests in single-species colonies are the strip census and the point-center quarter method. If more than one species is present, the distribution of nests and the certainty of identification of unattended nests will determine whether these methods are applicable. Both sampling schemes require walking through the colony, which causes disturbance that could result in loss of eggs and young. These techniques should be used only where disturbance will not seriously endanger the colony."

Disturbance

"Disturbance is a vitally important consideration to the health and welfare of a wading bird colony and deserves special emphasis. There are two kinds: direct disturbance, where humans actually enter the colony, and indirect disturbance, caused by human-related activities. As surveyors and census takers we are primarily concerned with direct disturbance."

"Most direct disturbance is caused by scientists, banders, photographers, and nature lovers. There is growing concern among biologists that their activities in a colony, which are directed toward ensuring the colony's welfare, are adversely affecting the birds. Schreiber and Risebrough (1972) found that frequent visits to a Florida Brown Pelican (*Pelecanus occidentalis*) colony significantly reduced the average clutch size and lowered hatching success by 28 percent to 41 percent in nests that were repeatedly checked compared to nests examined less frequently. In another study, hatching failure in Western Gulls (*Larus occidentalis*) was found to be directly proportional to the amount of disturbance in a study plot (Robert and Ralph 1975)."

"Any human intrusion can cause a loss of unhatched eggs and young to the elements or to avian predators. Young birds may be frightened and scramble from the nest to escape, thus making them more vulnerable to ground predators. Disturbed nestlings could wander into the territory of other adults and be attacked and killed. Displaced young from tree and shrub nests may not be able to climb back into the nest and may be neglected by the parent. The longer humans remain in a colony, the greater their impact will be."

"Bird colonies should never be entered during cold or rainy weather, and colonies in southern latitudes should not be visited during the heat of the day. Only a few minutes' exposure to the hot summer sun can kill embryos and young nestlings. Observers should remain in the colony for the shortest possible time. They should stay in a group and keep moving to allow the birds to fill in behind them. There is always a persistent danger of avian predators eating eggs and young while adults are off the nest. If the colony is not located on an isolated island, there is also a threat of mammalian predators following the human scent trail into the colony. Data recording should be carefully planned and completed so that no unnecessary trips into the colony will be made."

"A conscientious effort should be made by survey and census parties to minimize disturbance caused by aerial overflights. Fixed-wing aircraft and particularly helicopters if flown too close to a colony will cause birds to flush. Under normal operating conditions, this disturbance is short-lived, and the birds usually quickly return to the nests. Most colonial nesting birds will readily adapt to overflights, but desertion will occur if the colonies are deliberately and repeatedly disturbed."

Summary

"Surveying and censusing usually involve disturbance to nesting birds which may result in loss of eggs and young. Observers should be aware that their activities cause disturbance and make a conscientious effort to keep it to a minimum"

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Knight, R.L. and Knight, S.K. 1982. (Abstract) Effects of water-borne disturbance of wintering Bald Eagles. Abstract of 100th Stated Meeting of the Am. Ornith. Union. Page 37, No. 104. Chicago.

Authors Abstract:

"Behavioral responses of Bald Eagles (Haliaeetus leucocephalus) to water-borne recreational activity were studied in a disturbed and an undisturbed wintering area in western Washington. Using a factorial experimental design, we examined the effects of the age of the eagle, behavior of the eagle when approached, and the amount of human activity normally occurring in the area on the flight responses of eagles approached by canoe. Adult eagles showed a more intense response ($P < .05$) than immatures. The interaction of eagle behavior and amount of disturbance was found to be significant ($P < .05$). Eagles feeding or standing on the ground showed an intense response in both the disturbed and undisturbed drainages, while eagles perched in trees exhibited a less intense response in the disturbed than in the undisturbed area." (Department of Wildlife Ecology, University of Wisconsin, Madison, WI 53706, and 707D Eagle Heights, Madison, WI 53705.)

Kury, C. R., and M. Gochfield. 1975. Human interference and gull predation in cormorant colonies. *Biological Conservation* 8:23-34.

Authors' Abstract

The vulnerability of cormorant eggs and nestlings to gull predation is greatly increased by human intrusion into breeding colonies. Observations of the behaviour of double-crested cormorants (*Phalacrocorax auritus*) and king shag (*P. albiventer*) vis-à-vis the behaviour of great black-backed and herring gulls (*Larus marinus* and *L. argentatus*) on the one hand and dolphin gulls (*Leucophaeus scoresbii*) on the other indicate that certain predictable offensive and defensive interactions occur when breeding birds are disturbed. Knowledge of these behavioural patterns suggests that interference with normal breeding activities and the resulting reduction in productivity of cormorants can be minimised in colonies where human access is carefully regulated.

Introduction

"We found that cormorants appear to hold their own against the gulls except when disturbed from their nests by human visitors. A visit to an active cormorant colony can be a stimulating and rewarding experience for amateur naturalists, biologists and students, and should be permitted, providing due care is taken. Research on these birds also results in disturbance, but this can be minimised with prior understanding of how the two groups of birds interact. Thus we have observed that suitable controlled access can allow cormorant colonies to continue to serve an important aesthetic and educational role without their suffering long-term damage."

Results

"Whenever humans entered the colony a sequence of events occurred, as follows. Initially as the intruder approached, the gulls and cormorants became agitated and then left. The cormorants first raised their heads, teetered forward, and then launched themselves into the air (van Tets, 1965). Some departing cormorants regurgitated fish (principally cunner, *Tautoglabrus adspersus* (Walbaum)), and some young also regurgitated. During the alert phase adult cormorants sometimes stepped on eggs and crushed them, and occasionally kicked them out of their nests as they departed. Incubating adults left before brooding adults. While the intruder was in the colony, most of the disturbed cormorants remained on the sea nearby, while a few gulls entered the colony and ate regurgitated fish, cormorant eggs, and young cormorants."

"Very young cormorant chicks stayed on their nests, while older chicks (*i.e.* those whose first feathers were erupting) fled from the intruder, sometimes stepping on eggs as they ran. Young cormorants sometimes threatened the intruder, displaying like adults (van Tets, 1965), but with the gular pouch relatively more expanded. If cornered or handled, they struck the intruder with the bill, showing a preference for shiny objects, such as a watch."

"When the intruder left the colony, gulls swooped into the area and ate the regurgitated fish (Fig. 2) followed by the eggs and naked young (both those in nests and those kicked out). Soon the adult cormorants flew back, brooding birds generally arrived before incubating ones. The returning birds threatened the gulls that were at or close to (within about 1-2 m) their nests. The gulls then left the colony and the cormorants settled down to routine activities."

"Gulls were able to take advantage of the temporary desertion by the adult cormorants by entering the colony before the nesting birds returned. The most obvious form of defence, the parental threat display, broke down. However, other factors reduced the potential predation. Fish regurgitation, operating via the gulls' apparent preference for fish over eggs or young, and the neighbourhood effect, were two mechanisms for reducing loss."

"Observations during incubation (November 1971)—On approaching the concentration of cormorant nests a group of up to 30 dolphin gulls were seen to assemble, and when the observer reached about 25 m distance from the nearest nests, the gulls circled overhead and began to land just outside the colony. About 25 adult and 5 immature gulls walked back and forth patrolling the periphery of the shag colony (Fig. 3). At this time most of the shag nests contained incomplete clutches of 1 or 2 eggs (3 is the normal clutch size). When the observer approached closer than about 5 m, the nearest shags began to leave their nests, until about 10 rows of nests at the edge of the colony were left unguarded. An isolated satellite colony, approximately 6 nests wide and 17 nests long, was completely abandoned when approached to within about 8 m. Fleeing adults disturbed or broke eggs on only a few occasions."

"Even while the intruder was present the dolphin gulls moved in and took eggs from the furthest unguarded nests. Only about one third of the gulls actually entered the colony; they seemed wary and flew up if the observer took a step toward them. After 1 to 3 min Gochfeld withdrew, allowing the cormorants, most of which had been sitting about 20-50 m away, to return. Those finding gulls at or near the nest threatened or struck at them with their beaks, and they yielded immediately."

"Observations during the nestling phase (December 1970)—On 2 December 1970, many of the shag nests contained young up to a week old, as well as eggs. The adult cormorants were at this time much more tolerant of human intrusion and remained on their nests while observed from a distance of 2 m or less. They frequently gave aggressive displays toward the observer, but did not leave their nests until a move was made to touch them. On this visit dolphin gulls also followed the observer as he approached the colony, and remained on the perimeter where they were not threatened by the cormorants. When the cormorants were flushed, only a few nests near the observer were left unguarded, but the gulls nevertheless moved in quickly and took eggs. The cormorants returned quickly as soon as the observer withdrew even a step to two, and they then drove the gulls away. At this time there was no quantitative estimate of predation, but

it was clear that both gulls and cormorants were more tolerant of human presence than during the early part of the incubation period. Although naked young were about as numerous as the eggs in the shag nests, the gulls took no chicks, but ate about 15 eggs in the course of the day. A few bits of fish were lying around the colony, but fish-regurgitation was not noted, and the gulls seemed to be intent on obtaining eggs."

"*Impact of gull predation on king shag*—The significance of gull predation in the shag colonies is difficult to evaluate. It is probably not an important factor in relatively undisturbed colonies. However, continued disturbance would quickly allow gulls to reduce or eliminate a breeding population of the shag. Pettingill's (1960) observations of dolphin gulls preying on king shags in the Falkland Islands also stress the role of human disturbance, and Drury (pers. comm.) saw dolphin gulls take eggs from kelp gull nests after disturbance. Johnson (1938) reported gulls completely eliminating colonies of the common murre (= guillemot, *Uria aalga* (Pont.)) when human disturbance was frequent, indicating that the phenomenon is probably a general one. In view of the increased number of tourist visits to Punto Tombo (Boswall, 1973) there must be concern over the future of the nesting seabirds."

Discussion

"The behavioural interaction of gulls and cormorants in New England and northern Patagonia appears similar, differing possibly in the tactic of fish-regurgitation, which is an important defence mechanism of the double-crested cormorants but not apparently of the king shags. Reports by Bent (1922); Johnson (1938); Fisher & Lockley (1954); Pettingill (1960); Tinbergen (1960); and others indicate that opportunistic predation by gulls on nesting birds disturbed by human intruders is a general phenomenon, which may at times seriously affect the nesting success of the prey species."

"Fish-regurgitation appears to protect the nests of double-crested cormorants from predation because the gulls may become sated with fish before taking eggs or young. But repeated human disturbance, causing many birds to regurgitate on many days, might significantly harm growing young by depriving them of food. Thus, although nesting birds must protect or defend their young, fish-regurgitation is expensive in terms of loss of potential energy."

"In the New England and Punto Tombo breeding sites the advantage of colonial nesting was manifest in the neighbourhood effect, whereby cormorants protecting their own nests also protected those of their neighbours. Similar interspecific benefits have been reported for the sandwich terns (*Sterna sandvicensis* (Lath.)) and various species of ducks, nesting in association with aggressive species of Larids (Taverner, 1965; Vermeer, 1968; Dwernychuk and Boag, 1972)."

Conclusions

"2. Predation on eggs and young was negligible while adults were incubating or brooding, but increased greatly when they were flushed from their nests by human intruders. For both species there was some evidence that brooding adults were more tolerant of disturbance than were incubating adults."

"3. Literature review indicates that human disturbance facilitating gull predation on cormorants probably occurs wherever the two groups are together. Moreover, it has been reported for other seabird species that are subject to gull predation when breeding."

"4. Usually gulls prey upon unguarded or lost eggs and do not attempt to disturb sitting adult cormorants."

"5. After cormorants are disturbed from their nests, gulls may move into the colony to take exposed eggs, and it appears that they are somewhat more tolerant of human disturbance than the cormorants."

"6. Cormorants defended their eggs and young primarily by sitting closely, and they tolerated gulls patrolling close to the colony."

"7. When disturbed, double-crested cormorants frequently regurgitated fish, and the intruding gulls showed a preference for this food material rather than the eggs. Fish-regurgitation served as a means of protecting eggs, although under other circumstances it may help the birds to escape from predators by reducing effective wing-loading. During brief observations on the king shag, the strategy of fish-regurgitation was not noted."

"8. Both cormorant species showed a 'neighbourhood effect,' whereby some individuals threatened gulls that were close to, but not actually at, their nest. Thus they protected not only their own nest, but also that of a neighbour. If only part of a colony was disturbed, gulls avoided visiting unguarded nests that were near sitting cormorants, because the latter threatened them."

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Liddle, M. J., and H. R. A. Scorgie. 1980. The effects of recreation on freshwater plants and animals: A review. *Biological Conservation* 17:183-206.

Authors Abstract

This paper reviews the impacts of recreation on freshwater plants and animals. A distinction is made between water- and shore-based activities, and between physical and chemical effects. The impacts of water-based recreation, which result mainly from boating, are discussed in terms of wash, turbulence and turbidity, propeller action, direct contact, disturbance to animals, pollution from outboard motors and sewage. Those resulting from shore-based activities, such as angling and swimming, include trampling and associated effects, as well as sewage and other chemical impacts. The effects of management for recreation are also considered. There is relatively more information on the effects of recreational activities on plants than on animals, but the authors consider that further research is required in both fields. Some possible approaches are presented.

Water-based Activities

"Disturbance. All boating activities are potentially disturbing to some groups of animals. Research in this field is almost entirely restricted to the effects of disturbance on wildfowl (Cooke, 1976, 1977; Batten, 1977) and the response of fish to outboard motors (Lagar et al., 1950; English et al., 1963). Almost nothing is known of the effects of boating on other aquatic animals.

In a review of the impact of water-based recreation on wildlife, Satchell (1976) admits that although the destruction of aquatic vegetation indirectly affects associated populations of invertebrates as well as vertebrates, direct human disturbance appears to be more important in its effects on wildfowl populations'. He was considering shorebased activities in the main, but the same would seem to apply to disturbance caused by boating. This subject has been fairly well studied (Cooke, 1976, 1977; Batten, 1977) and comprehensively reviewed (Tanner, 1973, in press). Disturbance results either in redistribution on, or movement away from, the water body (Fig. 5). Movements may be more or less permanent, depending on the size and nature of the water body and whether there is a refuge, the type of activity and nature of the disturbance, its duration and the species and flock size of bird affected. In general, it appears that the effects of sailing are much less serious for those of power boat activities (Tanner, in press), although there are very few quantitative data in support of this view. Cooke (1977) states that only birds feeding or roosting in the deep central part of Grafham Water, Cambridgeshire, are forced to move because of sailing, and they usually experienced little difficulty in finding quieter conditions elsewhere on the reservoir. In another study on the effects of sailing on waterfowl, Batten (1977) has suggested that the decline of mallard *Anas platyrhynchos* in the Brent reservoir occurred after a side arm, which provided a refuge for wildfowl, was subsequently used for sailing. Thus, the critical factor in determining the effect of boating on wildfowl appears to be size of water body and whether boating takes place over the whole of the water surface (Tanner, in press)."

Shore-based Activities

"Disturbance. All recreational activities carried out on the shores of water bodies are potentially disturbing to animals living at the water margin and also to those sitting on the surface. Birds are apparently most seriously affected and other groups may be equally sensitive to public pressure, but, because they are less conspicuous and less easily studied, their responses may go undetected.

Most of the research in this area has centred on waterfowl and, in particular, on the effect of disturbance on breeding success. Satchell (1976) has reviewed some of the literature and makes the point that breeding failure is often associated with increased predation when the parent birds are kept away from the nest by disturbance. In one study of the effects of disturbance, Reichholf (1970) attributed an 85% decrease in the breeding stock of ducks in two lakes, over a period of eight years, solely to the activities of anglers. A. S. Cooke (pers. comm.) considers that anglers have essentially the same effect on wildfowl as boats; they create an area around them within which birds will not venture. Thus, an angler sitting on the shore can effectively exclude birds from his immediate vicinity, as the data produced by Cooke (1977) illustrate (Fig. 9). Given a sufficient density of anglers, even the most insensitive of birds may be prevented from breeding successfully. In a disturbed area, nest predation was significant even if disturbance was limited to 1 or 2 occasions per week (Morgan, 1972). The effects of other shore users can be expected to produce similar effects on wildfowl, but we know of no critical studies in this field. However, Cooke (1977) reports that disturbance caused to waterfowl by more than a thousand people (birdwatchers) visiting the nature reserve at Grafham Water over a two day period was slight and transitory. Total counts of wildfowl in the area made before, during and after the period were 2510, 2190, and 2350 respectively.

We have been unable to find any references to work that describes the effects of shore-based activities on other groups of animals. However, A. S. Cooke (pers. comm.) has determined the distances at which various passerine species take flight at the approach of humans. He found a correlation between the mean flight distance and size. In general, larger birds were less approachable than small ones so presumably, small birds, such as reed buntings and wrens, associated with the water margins, may be less sensitive to public pressure than the majority of wildfowl. Most of the smaller passerine species take flight when humans approach within 10 m, whereas wildfowl tend to fly up when people approach closer than a few hundred meters; for goldeneye Bucephala clangula this distance is 100 to 200 m (Hume, 1976). Large flocks (300 birds) of tufted duck Aythya fuligula and pochard Aythya ferina have been shown to ignore the presence of sailing boats that are more than 300 m away (Batten, 1977)."

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Lock, A. R. and R. K. Ross. 1973. The nesting of the Great Cormorant (*Phalacrocorax carbo*) and the Double-crested Cormorant (*Phalacrocorax auritus*) in Nova Scotia in 1971. Canadian Field Naturalist 87:43-49.

Authors' Abstract

Thirty colonies, containing some 4150 pairs, of the Double-crested Cormorant (*Phalacrocorax auritus*) were censused. Only ten of these had been censused previously and increases in size were noted in five. Twenty-three colonies, containing some 2050 pairs, of the Great Cormorant (*Phalacrocorax carbo*) were censused. Of the seven which had been previously censused, three had increased in size. Great Cormorants were found breeding on four islands south of their previously known breeding range and the populations of both species appear to be increasing. The Great Cormorants nest on cliffs or on the ground on rocky islets while the Double-crested Cormorants always nest on islands, usually in spruce trees.

Interference and Predation (p.48)

"Both these species show a quite low annual mortality after reaching sexual maturity (Kortlandt 1942, Hickey in Palmer 1962) and if not disturbed or persecuted should be capable of rapid population growth. However, not all colonies are as successful as the Guildford I. one. *P. carbo*, nesting mainly on bare rocks in this province, is particularly vulnerable to human interference, while *P. auritus* nesting almost entirely in trees, are relatively immune. Fishermen have a strong dislike for cormorants (most cannot distinguish between the species) believing them to eat salmon and lobster and to rob fishing nets and traps. Lewis (1957) has shown that these birds do almost no economic harm. It is likely that fishermen destroyed the eggs of the *P. carbo* colony on Hay I., where 92 of the 94 nests in the colony were empty on June 8. The rather low mean clutch size of the colony on Kennington Rocks, 2.06 eggs per nest on June 6, 1971, undoubtedly reflects some human intrusion. Human intrusion causing adults to leave the nest may lead to egg and chick mortality even if nests are not wilfully destroyed. Crows (*Corvus brachyrhynchos*), Ravens (*Corvus corax*), Herring and Great Black-backed gulls (*Larus argentatus* and *Larus marinus*) which are not normally very successful predators on cormorants, may in these circumstances successfully rob nests."

"Such predation may not, however, be an inevitable consequence of human presence. In this province lobster traps are set close to all the colonies of *P. carbo* and near to many of the *P. auritus* colonies also. The daily presence of boats close to these colonies causes little disturbance; only if one sets foot on the island do birds leave their nests."

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The Nature of ORV Impact on Desert Birds

"The impact of ORVs on desert vertebrates has recently been reviewed by Luckenbach and Bury (In press), and a more detailed discussion is found there. A conceptualization of the effects of ORV activity on desert birds is presented by Figure 1. ORVs can directly affect desert birds by nest destruction, crushing of individuals, harassment and noise production which could interfere with territorial establishment and maintenance (Luckenbach 1975, Luckenbach and Bury In Press). Subsequent habitat alteration decreases the overall amount and quality of shelter, foraging area, perches, nesting materials and nesting sites. Harassment and noise may force a parent bird to leave an active nest for long periods thereby exposing young to thermal and water stress. Since young birds are poor thermal regulators, mortality due to abandonment would be expected to be high. Edaphic disruption can cause erosion, compaction, de-armoring, and deflation which ultimately affect the germination of annual vegetation and insect and arthropod production. Many bird species which are principally seed-eaters become insectivorous during the breeding season or rely on insects to feed their young. Abundant sources of insects are critical to fledging success of many desert birds. Thus, the timing and success of breeding in desert birds is dependent upon the amount and duration of winter rains, which in turn influences production of annual wildflowers and perennial growth and the eruption of dormant insect and arthropod stages (Miller and Stebbins 1964, Luckenbach and Bury In press). Disruption of the seed bank in the soil or the water-retention capacity of the soil influences forage production in the spring which ultimately controls breeding success and carrying capacity of all desert vertebrates."

"Breeding success in desert birds is dependent on a number of factors, including securing and maintaining a territory, nest site, nest materials, mate, and a reliable food source. Certainly many species are adaptable and can accommodate some changes in any one of these factors. However, there is a threshold for each factor and for all of them working synergistically, after which it becomes impossible to nest or carry out the raising of a brood. Every avian species, whether resident or visitant, needs a different constellation of requirements to maintain itself and reproduce. A species' presence then will be predicated upon how closely the habitat provisions match its requirements. In a few instances, a single limiting factor can be identified; such as grit for gallinaceous species or cliff ledges for certain falconiforms. More commonly, however, a species is absent for reasons which elude detection or because of a "psychological requirement" which is not met by the environment. For instance, desert birds seem to respond more to the physiognomy of vegetation rather than the height or foliage diversity that is important to forest avifaunas (Raitt and Maze 1968, Tomoff 1974). Thus, minor structural changes in vegetative cover can have profound influence on an entire breeding avifauna."

Specific Studies

"To date, birds have been found to be the vertebrates most sensitive to ORV influence (Luckenbach and Bury In press). Bury et al. (1977) investigated breeding birds on plots with varying ORV damage in creosote (*Larrea divaricata*) scrub lands in the Mojave desert. At the Barstow site, the control plot had five times the number of breeding pairs and ten times the biomass of the moderately disturbed plot. On all sites ($N = 7$), moderate ORV use caused a 50 percent reduction in the number of breeding species, while the number of breeding pairs per plot was reduced by an average of 24 percent; average biomass per plot was reduced by 22 percent. The one heavily used plot had no breeding birds and received essentially no foraging use. Migrant and foraging use was lower on all ORV-used plot."

"Some habitat alteration in moderate-use areas may favor certain species (Bury et al. 1977). For this reason the horned lark (*Eremophila alpestris*) is little affected or else favored by ORV use. But this is largely because it is a ground-nester with a three-dimensional territory, preferring open, somewhat weedy habitats. As stated above, minor structural alteration in vegetative cover can have profound influence on the entire avifauna. A simplification in the number and condition of creosote bushes was found to reduce avian breeding diversity on the plots investigated by Bury et al. (1977). Thus the most important measure of ORV influence on breeding birds is the 50 percent loss in the number of breeding species that resulted from moderate ORV use. At best, diversity is sacrificed in return for favoring a few species. This figure could well be higher, as even the control plots of Bury et al. (1977) were not free of ORV use, but on a quantitative scale merely represented areas with the least amount of damage."

"Comparisons of breeding birds in two ironwood (*Olneya tesota*) washes were conducted in the Colorado-Sonoran desert of California. The control wash had a breeding bird density that was 23 times greater than the impacted wash. There was also a 90 percent reduction in the number of breeding species in the impacted wash. While the analysis of this data is still incomplete and full implication of ORV use as being causative in this case must be guarded, preliminary analysis shows that the gross differences are due to habitat destruction related to ORV activities in the impacted wash."

"No data are available on the possible impact of ORVs on upland game birds. In general, potential impact could come about through loss of food and cover, destruction of nesting and bedding areas, and harassment (Fig. 1). In California, several guzzlers for gallinaceous birds have been vandalized by ORVs and the surrounding vegetation damaged or destroyed. Such destruction not only jeopardizes the efficiency of guzzlers for water catchment and storage but also reduces nearby cover vital for wildlife (Luckenbach and Bury In press)."

Conclusions

"Though few studies exist on the effects of ORVs on desert avifaunas, what data exist show convincingly the detrimental and inimical impact on birds. Further, ORV activities affect not only the breeding components of desert avifaunas but, potentially, winter visitant and migrant species as well."

"Concentrating ORV activities in limited areas that have already received impact is viewed as the best alternative for short-term management programs. In addition, seasonal or statutory closures of areas critical to game, raptorial, endangered, and nesting-restricted species during breeding and fledging or during peak concentrations would also prove important in reducing conflict with sensitive species. At the same time, large prime tracts of habitat with diverse bird communities should be identified and protected to assure future sources for colonization."

"Lastly, it should be remembered that decisions made concerning the use of desert habitats by birds, potentially, could have import to segments of the avifauna of the whole of the western United States."

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Human Intrusions Pages 140-142.

During Breeding Season

"Breeding marine birds are probably most vulnerable to human disturbance. Actual vulnerability depends on which species, where it nests, and the kind of human activity. Surface nesting species such as gulls, terns, oystercatchers, and cormorants are especially vulnerable to actual visits by humans. When humans visit a surface-nesting colony or such birds as cormorants or gulls, they flush the adults off the nest and territory. Sustained exposure to the sun or cold and moist air may reduce hatching success and nestling survival. If gulls are present, eggs and nestling losses may be higher since they are predators. This kind of disturbance is very common wherever accessible marine bird colonies are situated near major human population centers. The large number of recreational boaters in the San Juan Islands, Washington, put pressure on the marine bird colonies of that area. Species most affected appear to be the Black Oystercatcher, Pelagic Cormorant, Double-crested Cormorant, and Tufted Puffin."

"There are very few published studies oriented toward this kind of human intrusion. Robert and Ralph (1975) experimentally disturbed a colony of Western gulls on the Farallon Islands, California. By varying the amount of disturbance (from 3 times per day to once per week) in several study plots, they found a dramatic relationship between frequency of disturbance and breeding success. A frequently disturbed plot had reduced hatching success over less frequently disturbed plots. Egg loss was due to destruction by neighboring gulls. During the chick period, survival of chicks was greater in plots more frequently disturbed. Robert and Ralph (1975) attribute this strange result to the fact that chicks in more frequently disturbed plots were somewhat more accustomed to the researcher and did not travel as far from the nest. In other plots, the young were more frightened, travelled further from the nest, and were thus more frequently killed by adult gulls."

"The results of direct human intrusion of tern colonies are similar to other surface-nesting diurnal species. These include egg and chick losses or widespread desertion (Buckley and Buckley 1972). Since terns are competing for nesting space with larger more aggressive gulls, tern populations in some regions of North America are declining. Few studies have dealt with direct human disturbance of tern colonies. An extensive study by Lloyd et al. (1975) on terns in Great Britain is very revealing."

"Cormorants either nest on ledges (Pelagic and Redfaced Cormorants), gentle or steep slopes (Brandts and Double-crested), or in trees and shrubs (Double-crested). Under normal conditions, cormorants have little problem with predators even though gulls often nest in close proximity. Losses usually are caused by severe storms (personal observation) or food failure. When cormorant colonies are visited by man, serious effects often result if a large number of gulls are nearby. Kury and Gochfield (1975) describe the

results of gull predation on cormorant colonies following human disturbance. Upon being disturbed, Double-crested Cormorants become agitated. In so doing, they frequently step on eggs or knock them out of nests. As the intruder gets closer, the birds flush from the nest, incubating birds leaving before brooding birds. A few cormorants regurgitate fish. Young cormorants usually run from the nest during which time they may fall off cliffs or get killed by circling gulls (personal observation). A similar situation exists with the King Shag (*Phalacrocorax albiventer*) in Argentina (Kury and Gochfield 1975) and in other species (personal observation)."

"Human disturbance of burrow-nesting species such as auklets and storm petrels is usually less severe than open-nesting species (gulls). The severity of direct human intrusion into nesting areas depends on the type of soil, slope, and whether the bird is diurnal or nocturnal. The most severe disturbance results from handling the birds in the burrow (discussed elsewhere) whether the species is diurnal or nocturnal. Our experience in the Pacific Northwest and Alaska is that diurnal species such as the Tufted and Horned Puffins are strongly affected by repeated human visits to the colony during the day, but not at night. Diurnal visits often result in high desertion rates among Tufted Puffins (personal observation)."

Effects of Field Research Page 143

"Biologists are also disturbance agents in most marine bird colonies. In general, disturbance is most severe during egg-laying in many species. The usual effect of human intrusion at this time is egg desertion. The brooding instinct is very strong in the majority of species, so there is less chance for birds to desert nestlings. In gulls, terns, and other surface nesting species, nestling losses may be high if disturbance occurs when young are mobile but not yet fledged from the nest."

"There is much variation in the responses of marine birds to human intrusion during the nesting cycle. Species that seem most vulnerable to disturbance from nest visitation are storm petrels, cormorants, gulls, terns, and alcids."

"We found that due to routine checks of incubating adults, 8 to 23 percent of Fork-tailed Storm Petrels abandoned eggs in the Barren Islands, Alaska. By checking burrows of Rhinoceros Auklets in Washington during egg-laying and early incubation, we forced 47 percent of birds in marked burrows to desert. We lowered desertion rates to 28 percent by waiting after hatching to check burrows. Desertion rates of 60 percent have been recorded in Tufted Puffin colonies in Alaska (Divoky, personal communication)."

"Gillett et al. (1975) show that their presence on a Glaucous-winged Gull (*Larus glaucescens*) colony in Washington State resulted in increased chick mortality (8 to 31 percent) but not in an increase in egg losses."

Military Activities Page 145

"Sonic booms from jet aircraft are linked to a dramatic breeding failure of Sooty Terns on the Dry Tortugas of the Caribbean Sea (Austin 1972). When a boom occurs, terns leave the nest in a "panic flight". This interrupts normal incubation and exposes eggs and young to the hot sun. Productivity dropped from 20-25,000 young to 240 (Austin 1972)."

Human Encroachment on Breeding Habitats Page 147

"Expansion of the human population into nearly all coastal areas of the United States has reduced marine bird populations over the past several decades. Nowhere has this been more severe than the northeastern coast of the United States. Buckley and Buckley (in press) have reviewed important aspects of this problem in the Long Island, New York area. Major vehicles of human encroachment are beach and estuary development, salt marsh alteration, and recreational pressure."

"Recreational use of actual or potential breeding sites may be more detrimental than commercial development (Buckley and Buckley, in press). Fishing, picnicking, hiking, ORVs, and abandoned pets create havoc in breeding colonies. In Washington State, where there is a huge number of small boats, there is much pressure on seabird colonies in the San Juan Islands, Strait of Juan de Fuca, and even parts of the outer coast (personal observation)".

"Real estate development on Protection Island, Washington threatens the state's largest population of Rhinoceros Auklets. Destruction of Rhinoceros Auklet nesting habitat, due to construction of roads and cabins has so far been minimal since the auklets prefer to burrow on relatively steep slopes. From an extrapolation of burrow densities, Wilson (1977) estimated that about 5 percent of the auklet population lost its nesting habitat due to these disturbances. In 1976, several hundred people owned lots on this island. Greatest visitation, however, occurs only on summer weekends. On holiday weekends, there may be more than 150 people on this 400 acre island".

Gull Encroachment Page 147

"The impact of gulls on other seabirds is less dramatic. Cormorants usually suffer egg and young predation and piracy of food brought back to the young. Only under the pressure from human disturbance does gull predation seem to have a serious detrimental effect (Kury and Cochfield 1975). Nettleship (1972) has shown that interactions between food shortage and gull predation and piracy seriously affected nesting success of the Common Puffin (Fratercula arctica) where puffins nested in suboptimal habitat".

Summary

"The effects of man on marine birds have drastically changed over the past two hundred years. Early encounters between man and seabirds resulted in local reduction in some seabird populations. Commercial eggging, hunting, subsistence exploitation, the introduction of predators to colonies, and a widespread encroachment of man upon coastal nesting areas characterized the early direct encounters between man and seabirds".

"During the twentieth century, direct human disturbance has been greatly reduced, especially at the colony sites. Modern technology has resulted in new indirect effects on seabirds that may be more serious than the direct disturbance of the eighteenth and nineteenth centuries. Oil pollution and chemical contamination of the oceans are now the most serious threats to seabirds".

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MacInnes, C. D., and R. K. Misra. 1972. Predation on Canada goose nests at McConnell River, Northwest Territories. J. Wildl. Manage. 36:414-422.

Authors' Abstract

Predation losses from nests of small Canada geese (*Branta canadensis*) were observed from 1965 to 1969, on a 62-square-km study area at the mouth of the McConnell River, Northwest Territories. The lack of significant regression of logarithm of clutch size at first observation on date indicated that partial loss of a clutch did not occur in the absence of disturbance by humans. Partial clutch losses comprised 55 percent of all eggs observed lost after repeated visits to individual nests. The proportion of nests completely destroyed did not vary among years, but the proportion losing some eggs did change significantly. The latter difference was due to changes in the activity of predators, or of their interaction with humans, and not due simply to changes in human activity. The number of eggs lost per visit was the same (0.65 egg per visit) for all clutch sizes except six, which lost 0.26 egg per visit. This resulted in greater total destruction of small clutches, because the eggs lost represented a higher proportion of the initial clutch. It was concluded that in the absence of human disturbance, predation losses of eggs would have been small (approximately 10 percent) and would have varied little from year to year despite demonstrated changes in predator activity. A major exception to this might occur because of a high arctic fox (*Alopex lagopus*) population, which was not observed in the course of this study.

Introduction

"A major difficulty in the estimation of natural egg loss arises when predators are accidentally assisted in finding study nests by actions of human observers (Hammond and Forward 1956). This problem is acute in arctic studies, where the low and sparse vegetative cover enables the common predators to detect disturbances at great distances. Jaegers (*Stercorarius* spp., chiefly *S. parasiticus*), gulls (*Larus argentatus* and *L. thayeri*), and arctic foxes are particularly attracted by human activity and learn to follow biologists in the field."

Survey Methods

"It became evident early in the study that parasitic jaegers were actively exploiting the opportunities provided when an observer drove the adult geese away from a nest (MacInnes 1962). We took no direct action to prevent predation but made our visits as quickly as possible to reduce the length of disturbance. Damaged eggs were recorded as destroyed, but we did not remove partially eaten eggs from the nest. Eggs were numbered with a felt pen. Each nest site was marked permanently with a small wooden stake placed inconspicuously to avoid attracting predators."

Results

"Thus, we concluded that partial loss of the clutch was entirely attributable to human-assisted predation, and in subsequent analyses we considered partial loss to be artificial."

"A consequence of egg loss per visit being largely independent of clutch size was that smaller clutches were more likely to be destroyed than larger ones. An average two-egg clutch will be gone after 4 visits, but at the same rate of loss, five eggs will disappear only after 10 visits. As₂ is shown in Table 8, small clutches were destroyed more frequently (χ^2 , 4df = 62.4, $P < 0.001$) than large clutches. Failure to recognize the cause of this relationship would lead to an erroneous conclusion if, for example, it were shown that younger geese laid smaller clutches and that the greater loss of these was interpreted as showing dependence of nest loss on age of the geese."

Discussion

"The major conclusion of this study is that predation losses would contribute little (about 10 to 12 percent) to the loss of productivity of Canada geese on the McConnell River study area if human disturbance was absent. In addition, the rate of loss would vary little from year to year, despite changes in predator abundance or activity."

"Possibly even this small loss is not correctly termed predation, since it may have resulted from nest desertion, with the avian *predators* acting only as scavengers. Jaegers and gulls rarely harassed incubating geese and were never observed to succeed in driving a Canada goose from her nest during this study. Thus, the only opportunity for egg-eating would arise when both geese left the nest area simultaneously to feed. During the egg-laying period, the adult geese were frequently absent from the nest for periods of several hours, and during this period blue geese lost many eggs (Cooch 1958:89). However, Canada geese covered their nests with extreme care before leaving, often taking an hour or more to arrange dead vegetation over the eggs. This rendered the nest difficult to detect even from a distance of 2 or 3 feet and presumably served to minimize the loss of eggs to predators. We were unable to detect whether losses during the laying period were heavier than during the incubation period, but observations were few because of the difficulty of finding unattended nests. Nests were conspicuous, covered or not, once incubation began and the female had deposited down in the nest lining."

"Arctic foxes might provide an important exception to the conclusion that predation would not be an important source of nest loss at McConnell River in the absence of human disturbance. However, the fact that heavy fox damage to Canada goose nests did not occur during nine (1959-61, 1964-69) seasons that biologists were at the McConnell River nest area indicated that serious predation by foxes would occur infrequently."

"In 1967, a single arctic fox destroyed, within 5 days, over 200 blue goose nests in 3 square km of the McConnell River study area. Students watched the fox systematically remove and bury eggs from one goose nest after another, until no active nest remained. Three of 30 Canada goose nests in adjacent areas disappeared during this period, but the fox was not observed near them."

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Indirect effects Pages 191-192

"Although there would probably be little actual nesting habitat loss for cliff-nesting species, human disturbance to colonies during the nesting period, particularly from helicopter and fixed-wing aircraft flybys, could have considerable impact (Sowl and Bartonek 1974). The "living waterfall" effect of thousands of seabirds pouring off a rookery is truly spectacular, but each such occurrence during incubation and brooding periods causes a rain of eggs or young to fall from the cliffs (Sowl and Bartonek 1974). Temporarily abandoned chicks and eggs are susceptible to predation by gulls or jaegers."

"Even for species nesting on level ground, aircraft overflights close to breeding colonies may cause major losses to young and eggs. Sladen and LeResche (1970) reported that flights by an LH-34 helicopter (at 305 m altitude) over an Adelie penguin (Pygoscelis adeliae) colony caused some egg loss. Landing this aircraft 183 m from the colony caused 50 to 80% of the birds to flee territories, resulting in egg and chick loss. Disturbance caused by visitors walking through or near nesting areas of the South African gannet (Sula capensis) on Bird Island, Lamberts Bay, South Africa, caused desertion of nesting sites (Jarvis and Cram 1971). Studies of disturbance on breeding black brant, Pacific eiders, glaucous gulls (Larus hyperboreus), and arctic terns at Nuneluk Spit and Phillips Bay, Yukon, in July 1972 indicated that human presence was the most critical form of disturbance affecting incubating behavior of these species (LGL Limited 1972a). Disturbance by aircraft-especially helicopters- affected the normal incubating behavior of all species except Pacific eiders. Nesting success of black brant and arctic terns was reduced by this disturbance."

"Disturbance can adversely affect molting birds. The process of molting places heavy energy demands on birds, and particularly on waterfowl whose molt results in a flightless period; few areas provide adequate protection from predators necessary during this period. Prime molting areas are scarce along the arctic coast, yet are vital to the welfare of thousands of sea ducks and seabirds. Studies conducted by LGL Limited (1972b) indicated that aircraft traffic over sea duck molting areas altered normal behavior, and therefore had a detrimental effect. Recommendations resulting from these studies were that air traffic be suspended over these areas during the molting season."

"For some arctic-nesting waterfowl, premigration staging activity, during which fat reserves to sustain southward migration are stored, is a very important component of the annual cycle (Delacour 1964). Snow geese, breeding mainly in arctic Canada, concentrate in large numbers on staging grounds along the Beaufort Sea coast of eastern

Alaska and the Yukon. Because gas compressor stations would be required along the proposed arctic gas pipeline route, experimental studies were conducted in September 1972 to determine the effect of disturbance from sounds generated by compressors (LGL Limited 1972c). These studies indicated that compressor noise was disruptive to staging geese."

"Indirect effects on marine bird resources resulting from development activities may ultimately prove to be more detrimental than the aforementioned direct factors. It is conceivable that the impact of these industries, mainly on the benthic and demersal fauna of the coastal areas, could greatly lower the carrying capacity of this habitat for marine birds (Bartonek et al. 1974). Because of the simplified and short arctic food chains and the lack of alternative food sources in these areas, arctic ecosystems would be particularly vulnerable to this type of problem (Burns and Morrow 1973)."

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Introduction P. 77

"Reactions of birds to observers have been studied frequently in recent years, primarily in terms of effects of disturbance on nesting success or on activities of the birds, and/or in terms of development in birds of tolerance of human activities (e.g., Bart 1977, Stalmaster and Newman 1978, papers in Rodgers and Burger 1981). Such studies sometimes also consider possible influences of such effects on conclusions reached in demographic studies, but reactions to observers are not usually used to measure some other behavioral parameter. Recently, however, several observers (e.g., Mossop 1971, Willie 1971, Hemus 1972, Donaldson 1973, Bergerud and Hemus 1975) have used reactions of Blue Grouse (*Dendragapus obscurus*) to observers as a measure of aggression in different populations. The underlying assumption in these studies has been that reactions towards human observers may be equated to the levels of aggression that the same birds would show towards conspecifics of the same sex."

Summary P. 82

"Reactions of 89 male Blue Grouse towards a single observer on 474 encounters are summarized. Most responses were some form of predator avoidance, with aggressive reactions very rare. Individual variation was marked. In birds encountered frequently, some suggestion of habituation was found, but this was not demonstrated conclusively. The marked individual variation, lack of aggressive responses towards a human observer, and difficulty in standardizing an approach to a particular bird suggest that the use of reactions to observers as a measure of aggressive levels in comparing populations is not reliable."

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Author's Abstract:

During the years 1972 to 1974, factors affecting the breeding biology of Common Terns (Sterna hirundo) were studied at five colony locations in the lower Canadian Great Lakes. At three of these colonies, no terns returned to breed in 1974, but at two other locations numbers remained stable or increased. We consider availability of nesting substrate reproductive failure, food supply, human disturbance, predation, and exploitation competition by Ring-billed Gulls as explanations for these observations. We conclude that whereas the most probable cause of desertion can be suggested for specific colonies, experimental work is required to identify the actual cause(s), which may be multiple.

Human Disturbance and Predation

Several authors have suggested that human disturbance (Austin and Austin 1956; Nesbit 1973a) and predation (Nesbit 1975; Hunter and Morris, in press) are factors contributing to reduced breeding success in Common Terns. None of the tern colonies which we studied was subject to extensive human disturbance, as all were either protected bird sanctuaries or on privately controlled land. Furthermore, our more frequent visits and consequent potential disturbance to the colonies on Lake Ontario and Lake Erie did not result in reduced breeding success or colony desertion as the Port Colborne colonies experienced relatively high breeding success.

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Breeding success (Pages 165-166)

"Hatching success is high, around 85% (Table 10), and in some groups, over 95%, though on Bonaventure Island it was much lower. If we assume that all eggs which are incubated beyond the maximum incubation period are infertile (which need not be so--some may be chilled, or the embryo killed in other ways), then 7.3% of 500 Bass Rock eggs were infertile and around 10% were lost before they could have hatched."

"Predation by the large gulls is completely insignificant. Indeed, in my experience it never occurs unless aided by some degree of human disturbance. This need not be blatant intrusion by man, leading to unattended eggs; a partly uncovered egg beneath an anxious adult can fall to the opportunist gulls. This needs to be stressed, not only because of its practical aspects but also because in some colonial species predation is important, and adaptations against it can partly account for the density at which the species nests. This does not apply to gannets and, since physical shortage of sites does not, either, determine nesting density, one has to look elsewhere for the explanation. In the same vein, comments on the supposed inferiority of fringe sites should be more critically examined, for although they do lose more eggs to predators, this is due to human disturbance, and not to any 'natural' factor."

The Gannet and Man--The Cull (Page 287)

"It was the Canadian colonies, in particular Bird Rocks, however, that suffered most catastrophically. Audubon found that 'the Labrador fishermen were in the habit of regularly visiting this great resort of gannets to procure their flesh for bait, armed with short clubs for the purpose of killing them. The frightened birds, prevented from rising into the air by their long wings, impeded each other's progress, by which numbers were overtaken and forced to the ground, the men beating and killing old and young with their clubs until too fatigued to go on any longer.' Audubon's pilot '... had seen six men destroy 540 gannets in about an hour.'"

"From 1904 onwards, the Canadian gannets were officially protected, as ours had been since the Seabird Protection Act of 1869, but prior to that it is little wonder that the world population of gannets had been savagely reduced in the 19th century; Fisher guesses by as much as two-thirds in 60 years."

"In the face of all this, present-day gannets are lucky to suffer little worse than disturbance and the isolated acts of vandals, though pollution (see below) and overfishing by man may yet be hazardous."

Nettleship, D.N. 1972. Breeding success of the Common Puffin (Fratercula artica) on different habitats at Great Island, Newfoundland. Ecological Monographs 42:239-268.

Gull - Puffin Interactions Pages 257-258

Egg Stage - Panic Flights

Egg displacement. - "Gulls cause puffins to leave the burrow in a hurry either directly (e.g., response to gull cries) or indirectly (e.g., response to puffin panic flights), with displacement of the egg to the burrow entrance (where it can be secured by a gull) as an occasional consequence. To determine the frequency of egg displacement on the two habitats we walked over slope and level nesting habitat on various parts of Great Island and recorded the position of the egg in burrows from which incubating birds were observed leaving in response to the disturbance created by our approach (e.g., gull cries). The results are given in Table 20. The frequency of egg displacement towards the burrow entrance was similar in the two habitats."

Panic-flight rate. - "The number of panic flights over the slope and level parts of the Main Colony were recorded through most of the incubation period (May 19-June 26, 1969) in observation periods of 60 minutes' duration. During 1,200 observation minutes (600 min/habitat) the number of panic flights was six from slope and 33 from level habitat. This considerably greater panic-flight rate from the level area of the colony is highly significant ($P < 0.001$, $t = 5.51$, $df = 9$)."

"An important point is that panic flights were usually initiated by gull activity (e.g., landing, takeoff, alarm cry) on level habitat, whereas on the slope it was most often a consequence of the commotion caused by the mass overhead exodus of birds from the level habitat, already in panic flight from their nesting area, out towards the sea."

Chick stage Pages 259-260

"From this point in the breeding cycle onwards, marked differences occurred in breeding performance of birds in the two habitats. Hatching success, and then fledging success, were distinctly higher on slope habitat. Overall breeding success was twice as high on slope habitat as on level habitat."

"The most important contributor to mortality of both eggs and chicks was gull predation, either presumed or observed; where not actually observed this was manifested as disappearance of the egg, during incubation, or chick before fledging, the only known reason for which is removal by gulls. This conclusion is based on numerous observations of adult gulls successfully taking puffin eggs and nestlings from burrows. Eggs found by gulls were either immediately pecked open and the contents eaten or carried off to another location to be eaten or presented to their young. When a chick was caught, it was usually held and struck repeatedly against the ground and then swallowed whole by the gull, often to be regurgitated later as food for gull chicks, or it was carried away and given to their young immediately."

"The higher frequency of panic flights on level habitat seems to be associated with differences in nervousness among the birds themselves. If panic flights are a consequence of the nervousness caused by the nesting area (Tinbergen 1931, Cullen and Ashmole 1963), it is to be expected that birds on inland level areas would panic more because of their poorer chances of escape from predators than those on maritime slope. This may also explain why adult distribution was concentrated along the crest of the slope on the Main Colony (strip 3), rather than matching the distribution of nest sites; presumably it is because take-off is quicker on slope than on level ground. The fact that the largest proportion of the surplus bird numbers on strip 3 apparently came from the level strips 5 and 6 (indicated by X^2 values, Table 3) fits this suggestion. A further consequence of this "psychological" effect of habitat is that the time interval between panic and return to the nest site by birds appeared to be greater on level habitat, and so exposure of any eggs displaced to the burrow entrance may be higher than on slope habitat where return to the colony is rapid."

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Nettleship, D.N. 1975. A recent decline of Gannets, *Marus bassanus*, on Bonaventure Island, Quebec. Canadian Field-Naturalist 89(1): 125-133.

Author's Abstract

A comparison of the results of recent surveys of Gannets on Bonaventure Island shows that after increasing greatly over the previous 80 years, the breeding population decreased from 20,511 pairs in 1969 to 17,281 pairs in 1973, a 16% decline. Reduced fertility because of contamination by toxic chemicals (chlorinated hydrocarbons) and disturbance at the colony by tourist boats and visitors on land seem likely to be prime causes. Past population data are reviewed.

Disturbance by Tourists

"The progressive increase in the number of tourists visiting the colony during the breeding season and the much higher volume of boat traffic viewing the colony from the sea at the base of the cliffs might have had some effect. Precise figures are not available to allow a detailed assessment of the increase in human disturbance, but the increase is almost certainly at least 100% since 1965. In 1973, the Percé Boat Association transported about 71,000 people around the island from mid-June to the end of September to view the Gannet cliffs (L. Brochet, personal communication). Allowing 25 people per boat-trip this means that at least 2800 trips were made. What influence this large volume of boat traffic has on the cliff-nesting Gannets is impossible to estimate at this time, but it is unlikely to be beneficial. But even if it does not influence the outcome of breeding attempts, observations made in 1974 indicate that it probably seriously disturbs non-breeding birds which are trying to establish sites on the cliff-face. A related factor, the exhaust fumes from the boats, might also have an adverse effect on Gannets. Both these factors either alone or together could conceivably lower annual production and reduce the rate of recruitment into the cliff-ledge sites."

"There is also the disturbance factor created by people visiting the Gannet colony on foot on top of the cliffs. While the increase in visitation on land is poorly documented, it too appears to have increased dramatically since 1965. At least 18,000 visitors landed on Bonaventure Island in 1973 (C.W.S. Bonaventure files), most of whom visited the Gannet colony during the critical periods of incubation and early chick growth (mid-June to mid-August). Ground surveys at the colony in 1974 with J.-M. Poulin indicate that cliff-top areas which receive heavy visitation have receded (i.e., Gannets absent in areas where they nested in 1966 and 1967), whereas some areas with little or no visitation are expanding (i.e. Gannets now nesting in areas which were without nests in 1966 and 1967). All this refers to tourists on foot on the top of the cliffs. Moreover, 1974 data of the behavior of people visiting the colony indicate that up to 25% of visitors do cross

the rope fences and by doing so disturb nesting birds (e.g. interrupt incubation, brooding and feeding of young, and cause the dispersion of chicks away from their nest-sites resulting in an increase in pre-fledgling mortality)."

"Combined, these factors alone could account for the observed decline in Gannet numbers and the differential loss in the two habitats. But there also remains the question of the importance of a changing food supply and other factors at sea."

Conclusions

"Much more, however, needs to be known about the factors mentioned above if causal relationships are to be elucidated. At present, it is only possible to conclude that the Gannet population decline at Bonaventure Island may be due partly to contamination by toxic chemicals at sea originating from the polluted St. Lawrence River, partly from an unmanaged visitation at the colony by people on foot and on the water by boat, and to one or more undetermined factors, possibly including changes in the availability of summer food."

Newton, I. and R. G. Campbell. 1975. Breeding ducks at Loch Leven, Kinross. *Wildfowl* 26:83-103.

Methods Pages 84-85

"The second project involved setting aside an undisturbed "control" area, in which no work was done till the end of the season. The aim here was to find whether our activities over the rest of the island had reduced nesting success there. One 100 metre square of *Deschampsia* was left undisturbed in 1969-1971 and the whole island in 1972-1973. In the event, neither project gave results that were unbiased, but they still helped to evaluate the main data. In total, nesting success in disturbed conditions alone was studied in 1966, 1967 and 1968, in undisturbed conditions alone in 1972 and 1973, and in both conditions in 1969, 1970 and 1971. Henceforth, the term "disturbed" is applied to areas worked during the nesting season, and "undisturbed" to areas worked only at the end. In general, no one except ourselves entered the colony."

Experiments with artificial nests Page 95

"The main way in which predation occurred under our disturbance was through providing extra chances for predators to take eggs while the mother was away, and we often saw Jackdaws removing eggs from nests just visited. Predators might also have found nests with the help of marker canes, as found by Picozzi (1975), who studied Crow predation on Red Grouse *Lagopus scoticus* nests. The situation at Loch Leven differed from Picozzi's because the main predators were Jackdaws, not Crows, and nest densities reached 100 or more per ha, much higher than Red Grouse, so even a short search by predators on St. Serf's was likely to be rewarding. Also our canes were left in place till the end of the season so, as the weeks passed, an increasing proportion were at finished nests, rather than occupied ones. Nonetheless, it was desirable to test for any possible influence of canes."

Discussion

Limitations on production of young

"The advantage of island nesting is generally held to be reduced predation on eggs, especially from mammals like Foxes *Vulpes vulpes*. This view could not be tested at Loch Leven because we did not study mainland nests, but in undisturbed conditions on the island, no more than 76-86% of nests in different years produced young. This was of the same order as in island nesting ducks elsewhere, and much higher than in mainland nesting ducks in most situations (Hammond & Mann, 1956, Dzubin & Gollop, 1972). At Loch Leven a major influence on the success of ducks was our own disturbance, which probably accounted for at least 9-14% of all clutches started and possibly twice as much. This was because Jackdaws, the main egg-eaters, were abundant and opportunist, raiding nests whenever the female was off. Similar bias presumably applied in some degree to much,

if not all, previous data collected on the nesting success of ducks, yet few attempts were made to assess its extent (exceptions include Balat, 1969; Reed, 1970; MacInnes & Misra, 1972). Irrespective of disturbance, however, several trends emerged. The most pronounced were the declines in clutch size and hatching success through the season, shown by all species."

"In conclusion, as a habitat for adult ducks, Loch Leven provided abundant space for territories and good nesting cover, but for ducklings it provided only restricted areas, which led to crowding, and may have accounted for the presumed heavy losses. The major recommendations for management of Loch Leven as a Nature Reserve were thus to (a) keep human disturbance on the nesting area to a minimum, and more important (b) alter the shoreline, so as to establish more cover and improve it for ducklings."

Summary

"5. Hatching success was reduced by our disturbance, which caused females to expose their nests to predators. Without disturbance, probably at most 76%-86% of clutches would have hatched in different years. The main egg-predators were Jackdaws *Corvus monedula* and to a lesser extent Moorhens *Gallinula chloropus*. Under disturbance, Gadwall were least successful. In all species, hatching success declined through the season, and was attributed at least partly to a seasonal change in the behaviour of the ducks themselves.

6. The hatching success of all species was better inside a large Black-headed Gull *Larus ridibundus* colony than outside it. This was probably because the gulls kept out other more serious predators. Tufted Ducks nested at greater density inside the gullery than outside, and in one year of exceptionally high density (215 nests in one hectare) its success was worse, not better, than outside. Under such crowding, many multiple clutches were laid and these had reduced hatching success."

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Reed, A. 1970. The breeding ecology of the Black Duck in the St. Lawrence estuary. Unpub. D. Sc. Thesis, l'Université Laval, Québec. 175 pp.

See also:

Livezey, B. C. 1981. Location and success of duck nests evaluated through discriminant analysis. Wildfowl 32:23-27.

Nichols, J.D., H.F. Percival, R.A. Coon, M.J. Conroy, G.L. Hensler, J.E. Hines. 1984. Observer visitation frequency and success of Mourning Dove nests: a field experiment. *Auk* 101(2):398- 402.

Introduction:

Field studies of nesting success generally require visits by the investigator to the nests under study. Such visits may themselves influence nesting success, however, and this possibility has been discussed and investigated by a number of workers with a variety of bird species. Livezey (1980) reviewed the relevant literature for duck nests and noted that most studies failed to demonstrate differences in nesting success between visited nests and those not visited. Livezey (1980) found in his own work that nest abandonment may have occurred as a result of disturbance by observers but that nest predation was not related to time spent by observers at nests or number of observers approaching nests. Various components of nesting and breeding success in seabirds are thought to be adversely affected by human disturbance and nest visitation (Gillett et al. 1975, Robert and Ralph 1975, Ollason and Dunnet 1980). Upland, ground-nesting species have also been studied (e.g. Stoddard 1931, Evans and Wolfe 1967, Henry 1969, Roseberry and Klimstra 1970, Klimstra and Roseberry 1975), and, although conclusions have varied, a number of these workers found no effect of observers on nest-predation rates.

The effects of human visitation on nest success in tree- and hole-nesting species have received some study. Willis (1973) found no difference between survival rates of visited and unvisited Bicolored Antbird (Gymnophrys bicolor) nests that were monitored by observation of adult behavior patterns away from the nests. Anderson and Storer (1976) found no relationship between nest-visitation frequency and nest success in Kirtland's Warbler (Dendroica kirtlandii). Using convincing field-experiment approach, Gottfried and Thompson (1978) and Gottfried (1978) found no difference in predation rates on experimental nests (abandoned nests of American Robins, Turdus migratorius, Northern Cardinals, Cardinalis cardinalis, and Field Sparrows, Spizella pusilla, were used) that were visited daily and those that were not visited at all. Using data from Cornell's North American Nest Record Card Program, Bart (1977) concluded that daily mortality rates of nests of American Robins, Eastern Bluebirds (Sialia sialis), and Mourning Doves (Zenaidura macroura) were higher the first day after a nest visit than on subsequent days during the nestling period. Bart and Robson (1982), however, later pointed out that these results could also be explained by an hypothesis involving unrecorded visits to nests. Specifically, they noted that ornithologists sometimes draw inferences about the state of a nest by observing it from a distance. Any evidence suggesting nest failure may prompt a visit to the nest, whereas the absence of such evidence may cause observers to stay away from the nest in order to avoid disturbing it. This behavior can result in an overrepresentation of fatalities in short-visitation intervals and an underrepresentation in long intervals, the same pattern that is expected under a "visitor impact" hypothesis. In any case, no general statement about the effects of nest visitation seems to emerge from previous studies.

In 1979 we began a study of factors affecting the nesting success of Mourning Doves at Patuxent Wildlife Research Center, Laurel, Maryland.

Discussion:

Our results are consistent with those of Gottfried and Thompson (1978) and Gottfried (1978), who also used an experimental approach to investigate the effects of nest-visitation frequency in habitat similar to ours. Gottfried and Thompson (1978:307) placed experimental nests in "sites that we think closely resembled nest sites of Cardinals, Chats, Mourning Doves and Field Sparrows. Most frequently selected sites were in multiflora rose, red cedar, and on the ground at the base of small cedars and saplings". Although we found no ground nests of Mourning Doves on our study areas, we found some nests in multiflora rose (*Rosa multiflora*) and many in red cedars (*Juniperus virginiana*). The principal difference between the studies of Gottfried and Thompson (1978) and Gottfried (1978) and our study involved our concentration on a single species and the presence of normal parental activity at our nests. Gottfried and Thompson (1978) examined a small sample of natural nests with parents (species not specified) and found that 18 of 30 succeeded (60%) compared to 79 of 119 experimental nests (66%). This difference was not significant, and they concluded that predation on natural and experimental nests was similar; the power of their test ($\alpha = 0.10$), however, was not extremely high (0.26 and 0.64 for true differences in success rates of 0.10 and 0.20, respectively).

Conclusions:

We conclude that, on our study area, success rates of Mourning Doves nests visited at daily and weekly intervals are very similar. We suspect that this similarity would also be true for other species nesting at similar sites in our study area (e.g. American Robins), as well as for Mourning Doves nesting in other areas having similar predators and levels of human activity.

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Introduction P. 39

Numerous seabird studies have dealt with the factors affecting breeding success (e.g., Coulson, 1966; Mills, 1973; Davis, 1976; Brooke, 1978; Ollason and Dunnet, 1978). Complementary to these studies is the investigation of causes and timing of breeding failures. Unfortunately it is impossible in practice to examine natural losses of eggs or chicks in isolation from unnatural ones because the observer's presence is likely to increase the losses, i.e., cause disturbance. However, the stage in the breeding cycle (egg or chick) at which losses are more likely to occur and their timing in relation to date can be determined.

Results - Disturbance P. 43

The presence of observers on Eynhallow likely caused disturbance to the breeding Fulmars, possibly resulting in lower hatching success and overall breeding success. In the years 1960, 1961, 1962, and 1978, the first annual visit covered about three weeks during laying, whereas in the remaining years from 1958 onwards, the May visit covered only 2 to 6 days. In all years, 2 to 6 people were present at this time. Since the egg stage especially is vulnerable to predation, the years with a long May visit might be expected to have a higher failure rate. This was the case, but the mean failure rates for the two sets of years were not significantly different at hatching (Table 1, a, b) or overall (Table 2, a, b).

Response of Breeding Adults to Approach of an Observer P. 46

The response of a Fulmar on an egg or a chick to the approach of an observer varied considerably. Some birds allowed an observer to see its color and metal bands and to remove an egg or chick for weighing without becoming disturbed or leaving the nest site. At the other extreme, birds left their nest site as soon as the observer appeared, and did not return while the observer was able to see the site.

P. 49

Thus the probability of breeding failure is increased if the parents are in poor condition or if their behavior is inadequate. External disturbance, whether intentional or not, exaggerates the losses by altering the behavior of the parents. Some species may be less susceptible, since their success is improved when they nest under cover (gulls, Brown, 1967; Lesser Black-backed Gull, Davis and Dunn, 1976; Common Tern, Nisbet, 1975). In others it is shown that adults nesting on the periphery of the colony fled more easily at the approach of an observer than those nesting in the center (Adélie Penguin, Tenaza, 1971). Also disturbance in one year can have an effect on breeding in the following year (Adélie Penguin, Oelke, 1975 and Reid 1968; Fulmar, Ollason and Dunnet, 1978).

Response to the Approach of an Observer P. 52

How does an observer cause disturbance? Significant differences between

birds are shown (Table 4) in the response to a particular observer at nests that subsequently failed (64% remained on site) and those that were subsequently successful (76% remained on site). The differences are similar to those described for the Adélie Penguin by Tenaza (1971), and the behavior of birds at unsuccessful nests is more erratic. Thus putting a bird off its nest an additional once or twice out of 10 occasions could make the difference between a successful and an unsuccessful nest.

The evidence indicates that the behavior of birds to the approach of an observer tended towards staying on the nest as breeding experience increased (Table 5), and this may be one of the factors that results in improved success of more experienced birds (Ollason and Dunnet, 1978), rather than being a consequence of it.

Effects of disturbance probably vary with species (e.g., Glaucous-winged Gull, Gillet et al., 1975; Double-crested Cormorant, Kury and Gochfeld, 1975), as well as with habitat (gulls, Brown, 1967; Lesser Black-backed Gull, Davis and Dunn, 1976; Common Tern, Nisbet, 1976) and frequency of disturbance (Western Gull, Robert and Ralph, 1975). Perhaps factors such as these should be considered when designing field projects.

Summary P. 52-53

Data were collected over 21 years as part of a long-term study of breeding Fulmars on the uninhabited island of Eynhallow in Orkney. The pattern of egg losses is described. Eggs laid early in the season were more likely to hatch than those laid late.

The relationship between number of observers each year and subsequent breeding success that year was examined. In four years in which 2 to 6 observers were present for 2 to 3 weeks during laying (May), hatching success and overall success were lowered, but not significantly so. No relationship existed between man-days present in May and breeding success. In eight years in which at least 12 observers were present for 3 to 4 days during hatching (July), hatching success and breeding success were significantly lowered. A significant negative correlation was found between man-days present in July and breeding success.

Capture of breeding adults had no significant effect upon subsequent breeding success of the population as a whole, probably because captures only occurred at about 10% of nests. The responses of sitting birds to the approach of an observer varied: at nests which were subsequently successful, 76% of birds remained on site: the figure for unsuccessful nests was 64% and their behavior was more erratic.

The causes of failure for a generalized seabird are described, and the Fulmar is fitted into this framework.

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Results

Responses to disturbance

"When mildly alarmed, Brent Geese put their heads up briefly, but quickly resumed feeding. When somewhat more alarmed, they stopped feeding for longer, sometimes walking away and calling. When severely disturbed they took flight, often resettling in the same place after disturbances by aeroplanes or loud noises, but usually leaving when disturbed by people on the ground. Geese re-alighted in dense flocks, gradually spreading out to feed, sometimes by further flighting away from the main group of birds. The disturbance behavior of a flock may be determined by the behavior of its most nervous members, since a few geese taking flight tended to cause the whole flock to follow. Adults with families spent more time with their heads raised. These 'sentinels', probably males, often first gave warning of potential danger, though they were not necessarily the first to fly.

Brent Geese were particularly susceptible to disturbance by aircraft, and any 'plane below about 500 m and up to 1.5 km away could put them to flight. Slow, noisy aircraft were especially harmful, and helicopters caused widespread panic. The geese were very slow to become habituated to aircraft, though at Leigh Marsh in January-February they did cease responding to the transport planes that took off regularly from Southend Airport. Other low-flying aircraft continued to cause disturbance throughout the winter.

Large birds with a slow wingbeat such as Great Black-backed Gulls Larus marinus, Herons Ardea cinerea and Hen Harriers Circus cyaneus were also liable to put the geese to flight. Even Carrion Crows Corvus corone landing near a goose flock caused birds to raise their heads briefly. The intensity of response to aircraft and their slowness to habituate to them may have been partly a result of the visual resemblance of aircraft to large birds. Kestrels Falco tinnunulus, Merlins F. columbarius and Sparrowhawks Accipiter nisus did not always cause disturbance, though geese sometimes flew up when these raptors caused waders to give alarm calls.

At low tide, disturbance was caused by bait-diggers, bird-watchers, and people walking out to moored boats or shellfish beds. At high tide disturbance was often caused by people on the shore. There was a decrease during the winter in the distance at which people at Leigh and Goldenhanger put Brent Geese to flight (Figure 3). Before New Year, about one-third of people approaching to within 100 m put birds to flight, whereas after New Year only 12% of people did so at this distance ($P < 0.001$). In early winter it was not possible to approach the geese more closely than 50 m. In January-March however, twelve observations were made of people coming within this distance, and on only four occasions were the geese put to flight. At Leigh, geese sometimes stayed on the ground when people came as near as 20 m to them."

"Experimental approaches to flocks of between 6 and 400 geese on the Norfolk saltmarshes showed that there was a tendency for larger flocks to take flight at greater distances ($r = 0.67$; $n = 22$; $p < 0.001$; Figure 4).

"Brent Geese learned the dangers associated with particular places. For example, at the Colne salting, much used by wildfowlers, geese in February could not be approached within 500 m, whereas the same geese could be approached to within 150 m on the Colne mudflats. Similarly, they were more easily disturbed when on novel feeding areas, such as fields behind the sea wall. For example, during an undisturbed 90 minute watch of birds feeding on winter wheat at Dengie on 8th January 1974 (soon after they started feeding over the sea wall), 34% of the time was spent feeding, compared with a mean of 59% on intertidal areas at Dengie. Large boats rarely caused disturbance, being generally in deep water. Even when they did come close, in the Colne estuary, the birds ignored them. Yachts, too, rarely disturbed Brent Geese, but small boats with noisy outboard engines caused them to take flight.

Brent Geese quickly became habituated to many sounds. Unexpected ones, such as nearby gun shots from wildfowlers, usually put the geese to flight. Similarly, the first shots of the day at the Colne Army ranges caused geese to leave the saltings for the mudflats. They quickly returned however, and ignored all subsequent firing that day. At Foulness, the extremely loud but regular bangs made during weapon testing caused little reaction after the first weeks. Brent Geese fed undisturbed 50m from passing trains at Leigh Marsh.

When disturbances occurred very frequently, birds appeared to become more easily disturbed on subsequent occasions. For example, three people walking on the *Zostera* beds at Leigh in November approached Brent Geese three times in the space of one hour. At the first approach, the birds flew up when the people were about 200 m away, at the second approach 600 m, and on the third at 800 m.

Disturbances by aircraft on average caused about twice as many geese to take flight as disturbances by people ($d = 5.3$; $p = 0.001$; Table 2), largely because of the area affected by an aircraft tended to be larger than that affected by a person on the ground. Taking into account their lesser frequency, aircraft caused about 1.6 times as much disturbance as people."

Feeding time lost

"Geese lost time from feeding by disturbance in all areas throughout the winter except at Leigh in late winter (Table 3). Over all areas, disturbance prevented geese from feeding for an average of 3.5% of their time. The greatest losses of feeding time were at weekends at Leigh and Goldhanger".

Effects of feeding behavior and flighting

"Disturbance would be harmful if it consistently resulted in birds losing more energy (through extra flying and lost feeding time) than they were able to make up by food intake. Disturbance was most intense at Leigh Marsh and the Blackwater. For example, at Leigh on weekends in 1974-75, geese were prevented from feeding for 11.7% of their

time and an extra 5.5% of time was spent in flight. On weekdays, the figures were 4.9% and 1.5% respectively. Ringing results have shown that some individual Brent Geese may stay in one area, and so experience intense disturbance, for 3-4 months at a stretch (A. St Joseph & T Bennett, pers. com.). The low digestive efficiency of geese (Owen 1972) and the restriction of feeding by the tide suggests that Brent Geese are likely to spend most of their available time feeding. Except in early winter 1974-1975, Brent Geese appeared to feed in daylight hours as intensively as tide and food availability allowed. Similarly, Rudge (1970) described Brent Geese on Foulness as spending an increasing proportion of their time feeding as the *Zostera* becomes depleted, spending all of the, shorter, days on the *Zostera* beds by mid-November. From about mid-November onwards it therefore seems unlikely that Brent Geese could have compensated for intense disturbance except by feeding more at night. Pink-footed Anser brachyrhynchus, Graylag A. anser and White-fronted A. a. albifrons Geese are known to increase their nocturnal feeding when intensive daytime shooting occurs (Newton & Campbell 1973; Owen 1972).

Nevertheless, poor winter food supplies may also result in reduced breeding performance in geese, for example in Black Brant (Cottam, Lynch & Nelson 1944) and Barnacle Geese B. leucopsis (Cabot & West 1973).

If Brant Geese were losing weight through food shortage, any disturbance could not be compensated for. Food shortage probably occurred in January-March, by which time the geese had become used to the proximity of people, though not used to 'planes, which caused more than half of all flighting. Moreover geese feeding on farmland were more wary and more easily put up than when on mudflats.

Although the overall impact of disturbance is probably not very serious at present, it is worrying that the two most disturbed areas, Leigh Marsh and the Blackwater, are also the two most important feeding areas in Britain in terms of goose numbers, apart from Foulness (K. Charman, pers. com.). It is especially important that increases in disturbance should not occur in these two areas. Zonation in the use of coastal areas in Essex may soon be required.

For example, people could be discouraged from walking close to the shore at high tide in certain areas, whilst yacht marinas, bait-digging, oyster beds, etc., could be concentrated in areas less important for wildfowl. The restriction of low-flying aircraft is even more important since Brent Geese are so slow to become habituated to them. Ideally, aircraft should not fly below 500 m over estuaries."

Summary

"An assessment is given to the effects of human disturbance on the distribution and behavior of Dark-bellied Brent Geese Branta bernicla wintering in Essex.

Disturbed areas and places with poor visibility were avoided in early winter, but were used later when other areas became depleted of food. Geese became partially habituated to the proximity of people and to some loud noises, but not to small low-flying aircraft.

The areas which contained the most geese apart from Foulness, namely Leigh Marsh and the Blackwater estuary, were also the most disturbed. Here, disturbance at weekends prevented geese from feeding for up to 11.7% of their time, and caused the time spent in flight to increase as much as sevenfold. Overall levels of disturbance were much lower than this, and would probably have been unimportant so long as adequate food was available on which geese could feed in undisturbed times, and at night. However, a shortage of food probably prevented complete compensation for the effects of disturbance."

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Parsons, K.C. and J. Burger. 1982. Human disturbance and nestling behavior in Black-crowned Night Herons. *Condor* 84:184-187.

Author's Abstract:

The effects of human disturbance on Black-crowned Night Heron (*Nycticorax nycticorax*) nestling behavior were studied at the Dead Neck island (Barnstable Co., Massachusetts) heronry in June and July, 1980. Nestling response to disturbance was compared between three-week old chicks that had been regularly handled since hatching, and control nestlings. Every control nestling moved some distance from the nest during the observation period, whereas all experimental chicks remained in the nest. Mean distance traveled by control birds was 1.0 m (range 0.2 to 3.6 m). Experimental chicks became habituated to frequent handling, whereas a single, intense disturbance elicited escape behavior in control nestlings. Weights of three-week old control and experimental nestlings were not significantly different. Repercussions of altered chick behavior in experimental animals are discussed and results compared to other studies.

Discussion:

Behavior of experimental nestlings was characterized by aggressive vocalizations and no movement from the nest, suggesting habituation. Several studies have shown that adult birds become habituated to disturbance (McNicholl 1973, Kury and Gochfeld 1975, Schreiber 1979). Robert and Ralph (1975) suggested that Western Gull (*Larus occidentalis*) chicks may become habituated to investigators. Our results show a strong tendency for frequently disturbed nestlings to vocally defend the nest against human intruders. Experimental chicks habituated to the extent that they did not run from their nests when approached closely by humans.

Since many studies of nestlings (e.g., growth analysis) involve repeated, high-intensity disturbance, the effect of infrequent, low-intensity disturbance has rarely been evaluated. The capability of nestlings to respond to repeated disturbance may explain why breeding success is generally less sensitive to disturbance during the chick-phase than the egg-phase.

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Discussion P. 10-11

The difficulty with examining systems of this nature is that the presence of humans may cause some aspects of the system to break down. Most gull predation upon eggs and young of seabirds (including conspecific predation) probably results from human disturbance (Dwernychuk & Boag, 1972; Bourget, 1973; Kury & Gochfeld, 1975; Fetterolf, 1977; Trapp, 1978; and personal observations). In areas where eiders nest in association with gulls, eggs are primarily taken from eiders' nests where humans have disturbed the female eider (Tinbergen, 1960; Graham, 1975). Essentially the same situation occurs in cormorants (Kury & Gochfeld, 1975; Trapp, 1978).

A similar situation may prevail on Great Island where human disturbance resulting from Nettleship's (1972) study and my own investigation may have had an adverse effect upon puffin breeding success. In fact, one important result of Nettleship's study may be accounted for by this phenomenon. Nettleship reported that puffins on Funk and Small Islands (where there was no interference by gulls) had significantly higher breeding success and fledging weights of chicks than did puffins on Great Island (Nettleship, 1972; Tables 23-25). However, Nettleship spent approximately six months on Great Island in 1969, and from late June until mid-September checked puffin burrows every four days (every two days just before fledging), whereas nests on Funk and Small Islands were only checked once in July and once in August, with only one day spent on each island at each time. Frequent disturbance by an investigator has been demonstrated significantly to lower hatching and fledging success in gulls (Fetterolf, 1977), and similar effects may occur in puffins.

In fact, the panic flights observed to occur in puffins on Great Island (Nettleship, 1972) are probably in part attributable to human disturbance. Both Nettleship (1972) and I observed that puffin panic flights often result from herring gull alarm cries. However, observations from a hide indicated that herring gulls on Great Island used these vocalisations only when a human being was visible in the vicinity. Puffins that were not in burrows did respond to some take-offs and landings of gulls by taking flight, but these disturbances were of far lesser duration and intensity than the wholesale panics which resulted from repeated gull alarm cries. This was particularly true when the gull cries were in response to a person walking through the colony, when many gulls would vocalise and take flight simultaneously.

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Poole, A. 1981. The effect of human disturbance on osprey reproductive success. J. Colonial Waterbird Group 4:20-27.

Summary: Page 26

"This study analyzed the effects of three types of human disturbance on the reproductive success of two coastal populations of nesting Ospreys: visits to nests by researchers; the trapping of breeding adults, and non-investigator human activity in the vicinity of nests. No correlation existed between increasing numbers of brief nest visits and several measures of Osprey reproductive success measured over a period of 4-7 years. Likewise, no significant differences were found in the number of young/active or successful nest between nests visited two or more times and those checked only from a distance by aerial survey. Limited data suggest that Osprey young are perhaps vulnerable to research disturbance during fledging and that climbing nest trees and poles in areas that harbor raccoons may increase predation."

"The trapping of nesting adult Ospreys, using appropriate methods and timing, did not adversely effect either their reproductive success or the growth of their young. Similarly, nests exposed to fairly continuous human activity in their vicinity produced young at rates equivalent to wilderness nests. Osprey nests most vulnerable to human activity are those in remote sites subjected to sporadic invasions of people; Osprey nest poles should be located so as to allow nesting pairs either early habituation or minimum exposure to human activity; wilderness nests should have human activity carefully controlled in their vicinity."

Reichholf, J. 1970. Der Einfluss von Störungen durch Angler auf den Entenbrutbestand auf den Altwässern am Unteren Inn. Vogelwelt 91:68-72.

Observation

"An indication of the effect anglers can have on water fowl distribution and abundance. On two small plots in West Germany, an 85% decrease in breeding ducks, was associated with disturbance by anglers during the breeding season. Dabblers disappeared completely from the study area."

Robert, H. C., and C. J. Ralph. 1975. Effects of human disturbance on the breeding success of gulls. *Condor* 77: 495-499.

Introduction

"A number of factors have been suggested as affecting reproductive success in gulls. In this study we have attempted to isolate the effect of human disturbance on breeding success. We held other factors such as age of birds, terrain, and density of colony as constant as was practicable with a varied colony environment. There have been several previous discussions of the possible effect of human disturbance on the breeding success of birds. However, no study has documented this effect with controls. Reid (1968) found that in the Adelie Penguin (*Pygoscelis adeliae*) 'banding and close observation during seven summers caused the breeding populations in six colonies . . . to decrease by more than 90%.' Nelson (1966), commenting on nests on the fringe of colonies, stated that their lower success rates did not take full account of artifacts introduced by human disturbance. Working with the Sooty Tern (*Sterna fuscata*), Ashmole (1963:324) said that 'mortality caused by the pecking of chicks by adults was increased enormously by any human disturbance of the colony.' Kadlec and Drury (1968:657) provided some information on the effect of human disturbance, and compared islands visited occasionally with those being studied in detail. Although they acknowledged an effect, they considered it insignificant compared to environmental variables. Hunt (1972), in studying four small Herring Gull (*Larus argentatus*) colonies, found that two colonies, frequently disturbed by picnickers, had lower hatching success than two undisturbed colonies. He found no difference in the ability of parents to raise young. These latter two studies most systematically approach the problem, but each compares totally different colonies that are, of course, under a variety of environmental conditions."

Summary

"This study suggests that under defined conditions, the presence of an investigator can be strikingly detrimental to breeding success. Hatching failure was found to be directly proportional to the amount of disturbance in a plot. However, mortality of young was inversely proportional to the amount of disturbance. The latter mortality was apparently the result of occasionally disturbed chicks reacting to the presence of the investigator by running into other territories and being attacked by adults. Young gulls that were more frequently disturbed were less frightened, and less subject to attack by adults. Overall mortality of young, comparing the completely undisturbed plot with a disturbed plot, was higher on the disturbed plot. Future studies of the effects of the environment upon breeding success in gulls might well take account of this source of mortality."

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Disturbance Page 246-247

"We did not witness any successful chases of Dovekies by Glaucous Gulls, but their reliance on Dovekies for food has been noted elsewhere (Salomonsen, 1950; Norderhaug, 1970). The behavioural effect of a passing Glaucous Gull on Dovekie colonies was very pronounced, particularly at the Cape Atholl study area where one passing gull was sufficient to send most of the thousands of birds perched on the colony flying out over the water. If passing gulls were frequent, the nesting slope was virtually devoid of birds for over half an hour. Even if the number of birds lost to gull predation is of minor significance, the associated disturbance may be important to success in reproduction. The behavioural reaction to passing ravens was quite similar to that for gulls. Glaucous Gulls were very numerous at the Siorapaluk colony during the period when Dovekie chicks were fledging, and undoubtedly reduced Dovekie fledging success."

"Arctic foxes were observed nearly every day at both study areas. On several occasions we saw foxes carrying Dovekie eggs or adults. Although they may have had a greater impact on productivity and mortality than gulls at Cape Atholl, they clearly did not elicit a high-intensity behavioural response from the birds. To a certain extent this was also true of the other important terrestrial predator, man. Foxes were frequently tolerated at a distance of 2 m without causing "panic flights". Dovekies were less tolerant of a person moving through the colony and usually flew off when the intruder reached a distance of 5 m."

"In addition to avian predators, mass panic flights were also elicited by the calving of glaciers and break-up of icebergs, actions which usually produced sounds similar to cannon fire. On several occasions we had the opportunity to observe the reaction of birds at the colony to low-flying aircraft (ca. 200 m). The response was higher than any observed reaction to avian predators or iceberg breakup. The most pronounced panic flight was in response to a U.S. Air Force C-141 jet on approach to Thule Air Base; almost the entire colony flew rapidly and silently out to sea, in contrast to the normal noisy circling seen in response to passing gulls. A period of 15 minutes elapsed before bird activity at the colony returned to normal."

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Rodgers, Jr. J.A. and Burger, J. 1981. Concluding remarks: Symposium on human disturbance on colonial waterbirds. J. Colonial Waterbird Group 4:69-70.

"Human disturbance of colonial waterbirds can be separated into two categories: non-scientific activities and scientific investigator activities. Included among non-scientific disturbances are recreational activities, such as photography and hobby banding, unleashed pets, feral animals (chiefly dogs and cats), habitat destruction or modification, and vandalism. Some habitat modifications, such as sanitary landfills and some agricultural practices, have benefitted certain species of gulls, herons, egrets, and ibises. The creation by dredging of new coastal islands (termed spoil or dredged material islands) has provided many species with suitable nesting habitat, and in some areas most colonial birds now nest only on man-made islands, often because the natural barrier islands are no longer available as nesting sites. Where terns and gulls still nest on barrier islands are no longer available as nesting sites. Where terns and gulls still nest on barrier islands they are frequently disturbed by dune buggies and jeeps being driven through their nesting sites. Least Terns, Sterna albifrons, are particularly vulnerable to vehicular traffic because they often nest on flat, open areas on the upper beach. Their nearness to human recreational beaches results in frequent disturbances. On island colonies picnickers and recreational photographers and banders may disturb colonies when mobile chicks are most vulnerable. Many colonial birds are exposed to cat and dog predation and the neglect of eggs and chicks caused by the presence of these animals in their midst."

"Impacts on the bird population resulting from these disturbances include egg mortality (hatching failure, predation), chick mortality (injury, loss of food, overheating, predation), lower nestling growth rates (from loss of food via regurgitations or reduced feedings from parents), modified chick behavior (premature fledging, increased agonistic behavior) and adults behavior (interrupted incubation and brooding, increased aggressive interactions), and colony abandonment. Additionally, human activities in a colony may delay nesting for some pairs, eliminate late-nesting pairs, or cause late-nesting pairs to shift to other less suitable nesting sites nearby, or to other colony sites."

"The presence of scientific investigators in a nesting colony can produce similar disturbance effects. Several of the papers in this symposium have discussed these effects, and some have shown as much as a two-fold increase in mortality or nest abandonment from frequent human disturbance. Some authors have suggested that for some species (see papers by Gochfeld, Burger, and Nisbet) frequent and regular disturbance may result in habituation of the birds to presence of the investigators. The degree and nature of habituation appear to vary from species to species, and circumspection is required to ascertain each species' response to human disturbance."

"For the researcher, two major factors must be considered when planning a project involving visits to a colony site: the effect of your presence on the birds themselves (mentioned above) and the reliability of the data you

obtain. There is no point in doing research if all we are measuring are the results of our own disturbance! Thus, we must choose methods of study with minimum impact on a colony to insure that the data we obtain are representative of the natural situation. Some species in certain circumstances may not lend themselves to study by investigators inside the colony. Some techniques may not be suitable to use. For example, cannon-netting in the breeding colony can be disastrous. Timing of visits may require modification. Visits of long duration in the warmest part of the day, or during inclement weather, are not advisable. Visits at breeding colonies associated with large numbers of predators (crows, gulls, etc.) should be avoided. Investigators should clearly describe the nature of their disturbance (e.g., chasing and picking up chicks, etc.), including the frequency and duration of intrusions, so that others can evaluate their data and conclusions. We should be suspicious of any research paper that does not comment on these various disturbance factors because every visit to a nesting waterbird colony causes some degree of disturbance."

"Many variables determine the degree of impact of human disturbance on colonial waterbirds. These variables include the species, habitat, type of colony, weather conditions, stage of the breeding cycle, presence of predators, other human activities, and the methods of the investigator. Much more research is needed in order to determine the potential and actual impacts of each of these variables. Contributors to this symposium have pointed out some strategies for minimizing disturbance by investigators. These include use of blinds, special entrances (tunnels), visitation methods (walking slowly, observation from the periphery), and reduced numbers and duration of visits. Some investigators working with herons have found that young who regurgitate food can be induced to reingest it, thus reducing loss of nutrients. Sometimes all that is necessary is to place the regurgitated food bolus in the nest where it will be eaten later. Disturbance caused mobility can be reduced by placing chicks under bushes and covering them with the palm of the hand until they crouch and cease attempting to run. Other suggested tactics are to avoid colonies with numerous nearby predators (especially crows and gulls) or nearby human activity."

"The knowledge of strategies for reducing adverse impacts on colonial nesting waterbirds is especially important to those who come in frequent contact with this group of birds - academic researchers, wildlife refuge and park managers, and agency directors who supervise personnel working in the field. We hope these symposium papers will alert each of us to the possible effects of our presence in a colony, to our responsibility as researchers to gather reliable data without causing modifications in reproductive biology, and to stimulate additional studies on the effects of human disturbance that will help us to develop methods to reduce or prevent these adverse impacts."

- Ryder, J. P. 1980. The influence of age on the breeding biology of colonial nesting seabirds. Pages 153-168. *In* Behavior of Marine Animals, Volume 4: Marine Birds. J. Burger, B. L. Olla, and H. E. Winn (eds.) Plenum Press, New York-London.

Discussion

"The main objective of this chapter is to review some of the relevant literature on the effects of age on the breeding biology of seabirds. It is clear in the literature that major trends include older established pairs usually arriving earlier at a breeding colony, laying larger clutches and eggs that, on average, produce more fledged young per season than do younger pairs or pairs nesting together for the first time. The psychological and physiological mechanisms underlying these trends are unclear and have not been tested rigorously in a wild population of seabirds. Such demonstrations will only be possible when the specific contributions of a number of factors known to control breeding success in social groups are quantified. The effects of weather (Ainley and Le Resche, 1973; Dunn, 1975; White *et al.*, 1976); predation (Nettleship, 1972; Manuwal, 1974; Hayward *et al.*, 1975; Patton and Southern, 1977); and more recently human disturbance (Ashmole, 1963b; Reid, 1968; Kadlec and Drury, 1968; Hunt 1972; Robert and Ralph, 1975; Gillet *et al.*, 1975) all influence the annual breeding success of colonial bird species * resulting in some nesting seasons being better than others in terms of * a natural rate of increase. Of greater importance are the ultimate * factors that control seabird numbers. According to major theses of Wynne-Edwards (1962), Ashmole (1963a), and Lack (1966), these populations are most likely regulated, in a density-dependent way, by the availability of food."

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Safina, C. and J. Burger. 1983. Effects of human disturbance on reproductive success in the Black Skimmer. *Condor* 85:164-171.

Introduction P. 164

The activities of researchers themselves at waterbird colonies may reduce the birds' reproductive success. Disturbance by biologists has been deemed a major threat to seabirds because their activities have caused desertion and mortality of eggs and young (Nisbet 1978, Schreiber 1979). Determining the effect of observers is important, because the validity of conclusions drawn from scientific investigation is diminished when an observer unintentionally and unknowingly influences the results. Knowledge of the phenomenon can also help to minimize adverse effects on the birds.

Natural losses of eggs and chicks cannot be wholly separated from artificial ones because the presence of observers may increase losses. However, the stage at which losses are most likely to occur can be determined (Ollason and Dunnet 1980), and this information can be used to minimize disturbance. Furthermore, the reproductive success of seldom disturbed birds can be compared to that of birds that have been disturbed more often. We designed a study to examine the effect of our field activities on all phases of the breeding season of Black Skimmers (Rynchops niger). We subjected subcolonies of skimmers to different disturbance schedules in order to determine when the birds were most affected by human disturbance.

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PRELAYING PHASE

Skimmers and many other colonial waterbirds are particularly sensitive to disturbance when it occurs early in the breeding season. When Ring-billed Gulls (Larus delawarensis) first return to breeding islands, they will not come ashore during the entire day if a human is present on the island in the morning (Conover and Miller 1978). Early season disturbance of American White Pelicans (Pelecanus erythrorhynchos) by low-flying aircraft lowered mean productivity from 0.80 young/nest to 0.22, whereas similar disturbance later in the nesting season reduced their productivity only slightly, to 0.74 (Bunnell et al. 1981).

Since many colonial birds nest in dynamic places (i.e., barrier beaches), which are subject to rapid change, it is adaptive for these species to be sensitive to changes in the site, including the presence of predators. Thus, if a traditional colony site were unsafe at the beginning of the season, the birds could move to a more suitable area. Desertion of an area by adults has also been noted as a response to early disturbance in Franklin's Gulls (Larus pipixcan; Burger 1981a), Black-crowned Night-Herons (Nycticorax nycticorax; Tremblay and Ellison 1979), and Caspian Terns (Sterna caspia; Fitch and Shugart 1981).

INCUBATION PHASE

In our study, skimmers also were sensitive to disturbance during the egg-laying and early incubation phases (Fig. 3). Thus, they deserted their nests most often before they had invested much time and energy in their

reproductive efforts. Other colonial waterbirds have also been found to abandon their nests or attempt less late nesting in response to observer intrusion (Buckley and Buckley 1972, Nisbet and Drury 1972, Conover and Miller 1978, Ellison and Clearly 1978, Manuwal 1978, Tremblay and Ellison 1979).

As incubation progresses, skimmers and other colonial waterbirds become less sensitive to human intrusion, desert less often, flush less easily, and return sooner when flushed (Johnson and Sloan 1975, Conover and Miller 1978, Manuwal 1978). Once birds have invested much time and energy in their eggs or young it is advantageous for them to continue since to abandon and renest elsewhere lowers their chances of reproductive success (Davis and Dunn 1976, Ollason and Dunnet 1978, 1980, M. Gochfeld, pers. comm.).

The hatching success of skimmers was significantly reduced in daily disturbed subcolonies (Table 1). Disturbance often makes it easier for gulls to steal or destroy eggs (e.g., Harris 1964, Johnson and Sloan 1975, Kury and Gochfeld 1975, Robert and Ralph 1975, Davis and Dunn 1976, Ellison and Clearly 1978, DesGranges and Reed 1981). We have no evidence, however, that predation by gulls increased because of our presence at Cedar Beach. Decreased hatching success in disturbed colonies has also been attributed to thermal stress caused by exposure of unattended eggs and chicks to heat and cold (Teal 1965, Hunt 1972, Ollason and Dunnett 1980), and eggs being crushed or knocked from nests by adults (Schreiber 1979). However, the significance of such factors is poorly documented (Cairns 1980). The most likely causes of egg mortality at Cedar Beach were heat stress and altered parental behavior. Teal (1965), for example, reported that a 30-min exposure to the sun was lethal to White Ibis (Eudocimus albus) eggs, and during our nest checks, adults were occasionally away for periods of time approaching this.

CHICK PHASE

Disturbance can affect the survival of chicks by increasing their vulnerability to predators and conspecific adults and by altering their behavior and that of adults. Gulls, for example, are often quick to devour exposed chicks (Harris 1964, Johnson and Sloan 1975, Kury and Gochfeld 1975, Davis and Dunn 1976, Ellison and Clearly 1978, DesGranges and Reed 1981).

Young birds in colonies are often killed by cannibalistic conspecifics (see Parsons 1971) or by adults defending their territories against chicks that wander from their own nests. Gillett et al. (1975) noted the importance of chick mortality caused by observer-induced trespass. In areas of Western Gull (Larus occidentalis) colonies subjected to different degrees of disturbance, Robert and Ralph (1975) found that survival of chicks was inversely proportional to disturbance because chicks that habituated, and did not flee from humans, were not killed by territorial adults. Nonetheless, chick survival was highest in completely undisturbed areas.

Chick mortality is also caused by thermal stress when parents leave in response to human intrusion (Gillett et al. 1975, Tremblay and Ellison 1979). Very young skimmer chicks often begin to gular flutter if exposed to sun for more than a few minutes on hot days.

Disturbance also causes chicks to leave their nests early. For skimmer chicks, human intrusion alone increases the distance that they move from the nest, and handling them increases it even more (Gochfeld 1981). Since skimmers nest in open patches of sand, such chicks often must cross through the territories of conspecifics or terns to reach the safety of vegetation. Chicks of Franklin's Gull and the Brown-hooded Gull (Larus maculipennis) also flee from observers and become lost or tangled in aquatic vegetation. In a study of Herring Gulls, chicks who were handled daily moved much farther than chicks handled weekly. They also ran immediately when approached, in contrast to those that were not handled, which did not flee until they were 20 days old (Burger 1981a). Teal (1965) found that ardeid chicks also left the nest abnormally early and moved farther away than otherwise if they were subjected to weekly disturbance.

Adults often exacerbate nest-leaving by calling chicks from disturbed areas; as noted in Sandwich Terns (Sterna sandvicensis; Veen 1977), Ring-billed Gulls (Conover and Miller 1978), Black Skimmers (Gochfeld 1981 and this study), and Caspian Terns (Fitch and Shugart 1981). One result of early departure from the nest is that smaller chicks may straggle behind their parents and become lost because they are so young (Vern 1977). Gochfeld (1981) reported that skimmers may lead three-week-old chicks up to 1.5 km away from the nest.

In our study, daily disturbance greatly depressed fledging success, unlike the case in certain other colonial waterbirds. Such disturbance, for example, did not prevent Herring Gulls, Black-crowned Night-Herons, or Black Guillemots (Cephus grylle) from successfully rearing young (Hunt 1972, Tremblay and Ellison 1979, Cairns 1980). We think that the main factor contributing to observer-induced mortality in skimmer chicks at Cedar Beach was their running from the nest at our approach.

MITIGATION OF OBSERVER EFFECTS

To minimize observer-induced losses while assessing reproductive activity, we recommend that biologists who are documenting the number of breeding pairs and their success rate should visit nesting areas only once during late incubation (when adults are least likely to desert and will return to the nest soon after the disturbance), and count fledged young at nearby loafing sites with the aid of a telescope. Several other investigators have made similar suggestions (Johnson and Sloan 1975, Kury and Gochfeld 1975, Ellison and Cleary 1978, Tremblay and Ellison 1979).

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Introduction P. 55

Florida is regarded as the most important breeding area for southern Bald Eagles (*Haliaeetus leucocephalus leucocephalus*) (Sprunt 1954, Sprunt et al. 1973, Robertson 1978). Some of the densest breeding concentrations historically occurred along the now heavily urbanized middle Gulf and Atlantic coasts of the peninsula (Robertson 1978). These coastal populations are now greatly depleted or extirpated. Statewide, populations have decreased by at least 50% during the past 30 years (Robertson 1978).

Nationwide, declines in certain Bald Eagle populations have continued in spite of reductions in chlorinated hydrocarbon pesticide use. Direct loss or deterioration of suitable habitat resulting indirectly from human activity may have replaced pesticide contamination as the major contributing factor in the decline of the southern Bald Eagle (Murphy and Coker 1978, Robertson 1978). Our study was initiated in an effort to ascertain the relationship between project construction and the status of Bald Eagles nesting in the Kissimmee Basin, and to provide a basis for assessment of the potential impact of system restoration on this endangered species.

Summary P. 61

We analyzed the status of southern Bald Eagle (*Haliaeetus leucocephalus leucocephalus*) nesting during and after construction of a flood control project in the Kissimmee River Basin in central Florida. A 74% decrease in the annual number of active territories was observed following construction of this flood control project in that segment of the study area where disruption of aquatic ecosystems and, therefore, a prey base for eagles, was most severe. Productivity of eagles nesting in all three sub-basins was comparable to that of eagles nesting in central Florida and statewide between 1977 and 1979.

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Results Page 17 (Unpublished)

"Human presence on Egg Island is thought to have increased the predatory success of glaucous gulls. When eider nests were examined for clutch size or pipping young, the glaucous gulls invariably returned to the island before the eiders. Although the eggs were nearly always covered over with down, it is thought that the unnatural absence of the female eider gave the gulls an increased opportunity to steal the eggs. It was also discovered that if a female eider was followed by a duckling when she flushed, the nest was permanently abandoned. The female led the duckling to the water and did not return to the nest. This also increased the predation of eggs."

Other nesting birds were noted on Egg Island. Twelve glaucous gull nests were located. The first pipping was noted on July 9 and all eggs are believed to have hatched by July 16. The chicks remained in their nests, or in the immediate vicinity of their nests, for several days before roaming freely over the island. These chicks did not seem to fear human presence, for they made no effort to hide while mapping procedures were conducted close to them."

Sowl, L. W., and J. C. Bartonek. 1974. Seabirds—Alaska's most neglected resource. Trans. N. Am. Wildl. Nat. Resour. Conf. 39:117-126.

Introduction

"There is no coordinated program for seabird management in North America. Management of seabirds in Alaska has historically been passive and piecemeal in nature and usually limited to the acquisition of lands for protection of breeding colonies. Even this protection has been generally directed towards the spectacularly conspicuous colonies of cliff-nesting species. The acquisition of breeding areas for those seabirds whose nest sites or habits are less conspicuous has been largely accidental. Management information has for the most part been haphazardly gathered, with investigations often being dictated either by the interests and orientation of the investigators or by the pressures of the crisis at hand."

The Value of Seabirds

"Seabirds transfer and recycle nutrients and energy between trophic levels and between regions of the ocean. The significance of this role in the marine ecosystem can only be surmised from a few conservative estimates such as Sanger's (1972) that birds consume from 0.6 to 1.2 million tons of food and return from 120,000 to 240,000 tons of feces into the Subarctic Pacific Region each year."

"Seabirds could provide protein for nonnative as well as native diets on either a commercial or a subsistence basis. The possibility also exists that seabirds could help divert a portion of the sport hunting pressure from waterfowl. Sociological problems will probably arise from consideration of either possibility even if it is shown to be biologically feasible to manipulate seabird populations through these means."

Interactions and Conflicts Between Seabirds and Uses of Other Resources

Livestock

"Livestock, domestic cattle, sheep, and reindeer, are known to cause depletion of ground-nesting birds when the livestock numbers on a range are too great or their movements uncontrolled. They destroy nests by stepping on them or by removing the cover and exposing the nests and incubating birds to increased predation. Burrow nesters are often subjected to trampling of their burrows which also causes disturbance and loss. This type of impact could become more significant as grazing of seabird nesting areas becomes more profitable."

Disturbance From Other Activities

"Seabirds nesting on cliffs are highly susceptible to disturbance. The incautious, close approach of aircraft, boats or people on foot almost invariable results in a panic flight of birds from cliffs. During incubation and brooding each occurrence causes a rain of eggs or young to fall from the cliff. Other chicks and eggs that are temporarily abandoned fall prey to gulls and other predators."

Conclusions

"Seabirds have been virtually ignored by oceanographers, marine biologists, ornithologists, and resource managers. Rapidly increasing demands are being placed on marine ecosystems through increased exploration of marine resources and pollution."

"Resource management, passive for many years, is now showing signs of developing into a more active program. This program development will be hampered by a lack of basic data for some years to come. Basic life history and population dynamics must be studied before inventories can be refined. There is already a gap between requirements for data and the ability to supply it."

"New international agreements and an up-to-date law of the sea will be vital to future management, which for many species will have to have an international base."

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Thompson, D. 1973. Feeding Ecology of Diving Ducks on Keokuk Pool, Mississippi River. J. Wildl. Manage. 37:367-381.

Author's Abstract

From 1966 through 1968, a study was conducted to investigate the relationships between diving ducks and their food resources on the Keokuk Pool of the Mississippi River. This information was needed as a baseline from which to measure the impact of channelization on food resources of diving ducks. Nearly 20 million diving duck days were recorded during each year by aerial and ground census. Night dispersal and feeding seemed particularly important to diving ducks since disturbances caused the concentration of 90 percent of the waterfowl on 28 percent of the study area during daytime. Molluscs, especially fingernail clams (*Sphaerium transversum*), were of paramount importance as food for five species of diving ducks. The analysis of duck esophageal contents collected during spring indicated that diving ducks ingested larger benthic organisms until large items became unavailable due to intensive predation. The combination of estimates of food consumption by diving ducks and benthos data indicated diving ducks possibly harvest 25 percent of the benthic standing crop during fall. The future of this important migration stopover area largely depends on the preservation of the rich molluscan fauna.

Results

"Diving ducks tended to concentrate in 16 areas which composed 28 percent of the open water of the entire study area and ranged in size from 50 to 700 acres with a mean of 290 acres (Fig. 1). Based upon ground counts, about 85 percent of flocks over 500 birds and 98 percent of flocks over 15,000 birds occurred on these 16 areas."

"Through indices derived from ground counts, distinct seasonal changes in occurrences of flocks on the concentration areas were noted. When waterfowl use (Table 1) was compared with levels of human disturbance (Table 2) it was obvious that sections with greater human disturbance had lower use by ducks."

"In general, the diurnal distribution of waterfowl in fall seemed unrelated to density or distribution of vegetation or benthos."

Discussion

"On the heavily polluted and altered Illinois River, the disappearance of diving ducks appeared closely related to the disappearance of their food supply, primarily sphaeriids (Mills et al. 1966). The Illinois River commercial fishery, of which carp were a major component, declined steadily over the same period."

"One can conclude, if the Keokuk Pool resource is destroyed by siltation, chemical or thermal pollution, stream deepening, water diversion, or a series of such modifications, use of the Keokuk Pool by diving ducks will stop."

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Titus, J. R. and L. W. VanDruff. 1981. Response of the Common Loon to recreational pressure on the Boundary Waters Canoe Area, North-eastern Minnesota. Wildlife Monographs No. 79. 59 pp.

Introduction

Page 7

"Another human factor often presented, but for which little experimental data or evidence have been collected, is that of the effect of recreational use of lakes on breeding loon populations. Olson and Marshall (1952) mentioned that recreational use of wild areas is perhaps the major reason for the unsuccessful nesting of the common loon. Ream (1976) also suggested that increased use of lakes and island campsites by canoeists caused most nest failures of common loons in the Boundary Waters Canoe Area of Minnesota. Barr (unpublished dissertation), Ridgely (1975), Sutcliffe (1978b), Trivelpiece et al. (1979), and Yonge (1975) attributed declining numbers of common loons to increasing use of lakes for cottages or recreation. Lehtonen (1970) indicated that similar factors were responsible for the decline of arctic loons, *Gavia arctica* in south-western Finland. Vermeer (1973b) observed that the common loon in Alberta is intolerant to human disturbance, and for that reason the bird may serve as a unique indicator of the wilderness quality of specified lakes and regions. More recently, McIntyre (1979a) considered Minnesota loon populations stable. However, she suggested that the decline of loons in New Hampshire is a direct result of lake use and lakeshore development (McIntyre 1978), and that recreational use and development of lakes pose a potential threat to all loon populations (McIntyre unpublished). Similar effects in the Adirondacks of New York and the Northeast are described in popular articles by LaBastille (1977), Mays (1976), and Taylor (1974).

The solitary lakes and waterways of the Boundary Waters Canoe Area have in the past offered protection from human interference to many wildlife species, including the loon. However, in recent years, that area has received tremendous recreational pressure from fishing, canoeing, and camping enthusiasts. Overuse is beginning to threaten the ecosystem and overcrowded conditions are decreasing the esthetic returns for the camper who seeks a "wilderness" experience (Gilbert et al. 1972)."

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Summary:

"Nest site data were used to calculate indexes of human use, human impact, disturbance potential, visibility and vegetational cover. A population of 151 loons (64 nesting pairs) on 29 lakes produced 140 nests over the 2 years, for a mean hatch of 0.79 chick/breeding pair/season. Of the 140 nests, 40 percent were successful; whereas 71 of 88 young produced (81.7%) survived to fledging. Island and mainland nest sites were equally productive. However, a significantly greater hatch/egg laid was observed for smaller (usually remote) lakes; and loons on lakes where motors were prohibited were more successful at hatching eggs ($P < 0.05$) and producing broods ($p < 0.10$) than those on lakes where motors were allowed. Less visible nests produced significantly more ($P < 0.05$) hatched eggs than more visible nests. Comparisons of nests near high and low human use showed that loon pairs experiencing fewer human contacts produced significantly more ($P < 0.001$) surviving young. Nevertheless, not all indicators of productivity supported the hypothesis that heavy recreational use of lakes was detrimental to the nesting and brood rearing of the loon. In fact, some analyses showed little or no effect of heavy recreational use on loon productivity. Only a slight negative effect of motorcraft on nesting and brood rearing was seen. Many birds in areas of high human use (usually lakes on which motors were allowed) refused to leave the nest when approached by humans. Loons on nests on remote lakes always flushed. The extent to which the loon may be adapting or habituating to human disturbance remains an exciting question. Although an 800-900 percent increase in recreational use of the area has occurred over the past 25 years, a 35 percent increase in adult loons has been noted; loon density is also comparable to that found in similar (remote) areas. The conclusion is that human use of this wilderness area slightly reduces the nesting and brood rearing success of individual pairs in areas of high human impact but because of undisturbed loon pairs or pairs habituating to human use, the size of the adult breeding population during the past 25 years has not declined. The findings of this study should not be applied to loon populations in more developed areas."

Tremblay, J., and L.N. Ellison. 1979. Effects of human disturbance on breeding of Black Crowned Night Herons. Auk 96:364-369.

Author's Abstract:

"Visits to Black Crowned Night Heron (*Nycticorax nycticorax*) colonies just before or during laying provoked abandonment of newly constructed nests and either predation of eggs or abandonment of eggs followed by predation. Investigator disturbance caused mortality of young in some situations. Frequent disturbance also discouraged the settlement of late-nesting night herons, late clutches being more likely in colonies visited only twice than in colonies visited 10-15 times. Clutch size and fledging success of successful early nests were the same in frequently and infrequently disturbed colonies."

Introduction

"Several experimental studies have demonstrated adverse effects of human disturbance on reproductive success of gulls (Kadlec and Drury 1968, Hunt 1972, Robert and Ralph 1975, and Gillett *et al.* 1975) and cormorants (Ellison and Cleary 1978). In some studies of the Ardeidae it was suspected that human visits reduced breeding success (Jenni 1969, Wolford and Boag 1971), but no control colonies were checked to verify the effect. Goering and Cherry (1971) found no difference in success of various species of heron nests visited 16 times and those visited four times. We report here on effects of initiating visits to night heron colonies early in the nesting season and we also discuss differences in colonies visited 10-15 times and those checked only twice."

Results

"We conclude that failure was partially due to initiating visits before laying began, causing inhibition of laying, abandonment of nests, and perhaps egg predation. The nest abandonment and egg predation lead to a high failure rate of active nests before hatching (48%). The high failure rate of nests after hatching (31%) suggested that our visits also induced mortality of nestlings."

"The blind on Gros Pêlerin permitted us to confirm in 1976 that night herons may abandon young after human disturbance. We observed that the parents did not return to a nest containing three 2-4 day-old young in the hour following our visit on a cold, windy day, and the nest was empty when checked a few days later. In fact, at the time of this next visit, 5 nests formerly with young were empty and a total of 25 nestlings had disappeared or were found dead, these 25 representing 73% of all nestling mortality occurring in the colony that year. We do not know if this visit caused only nest abandonment or also mortality of young by exposure."

Discussion

"Our visits to experimental colonies reduced nesting success by inhibiting laying, by increasing either nest abandonment or egg predation, and by increasing nestling mortality."

"The late nests in the controls on Gros Pèlerin suggested that another effect of human interference is to discourage late nesters from settling in disturbed sites. This same effect was noted in a similar comparison of experimental and control colonies of Double-crested Cormorants on Gros Pèlerin (Ellison and Cleary 1978)."

"The comparison of experimental and control night heron colonies showed that those adult herons remaining to nest in disturbed areas incubated normal clutches and reared normal sized broods, a result also noted in the study of Double-crested Cormorants (Ellison and Cleary 1978). Thus data on clutch size in the experimentals should be valid if clutches diminished by early abandonment or predation are eliminated. Similarly, data on number of young fledged per successful nest should be representative of early nesters. If late nesters lay smaller clutches or raise fewer young than early nesters, however, data on reproductive performance of a frequently visited colony will be biased. Data from disturbed areas expressed as proportion of laying attempts that were successful, for young fledged per laying attempt, will also be biased, regardless of whether or not there are late nesters."

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Author's Abstract:

"Blackheaded gulls Larus ridibundus L. in juvenile plumage were less efficient foragers than adults and usually were defeated in intraflock conflicts by adults. Juveniles in flocks with no adults present foraged more efficiently than juveniles in flocks with adults. The difference is supposed to be due to interference from the adults. Adult gulls in eclipse plumage foraged as efficiently as adults in nuptial plumage but were socially inferior to them. After disturbance adults landed more quickly but farther from the observer than young birds."

Observational Procedure: Page 161-162

"In addition I assembled data on the behaviour of the gulls upon disturbance. Flocks frequently took off, sometimes because of some obvious disturbance but more often for a cause imperceptible to the observer. In a number of cases I was able to record the age distribution of the first dozen or so birds landing after disturbance; after about that number had landed and resumed feeding, the scene became too confusing for such data to be collected. In a few flocks the birds were particularly fearless, and since furrows provided a gauge for demarcating an "area nearest to the observer", I took this chance of recording the age distribution of the birds landing within this arbitrarily designated area. The age distribution of the birds landing first and nearest, respectively, was then compared with the age distribution of the whole flock.

The observations were collected in July and August, 1978, in the province of Halland in SW Sweden and around Uppsala in central Sweden."

Observational Data:

"Tab. 3 gives the age distribution of the first birds to land after disturbance. If one pools the 2 to 4 incidents recorded for each flock, as may be justifiable with respect to the low proportion of the flock members involved in each incident, the overrepresentation of AD birds in the samples is highly significant in all cases except one (χ^2_1 , two-tailed)."

"Finally, Tab. 4 presents observations showing that in three flocks of four (incidents being pooled as above) JUV were overrepresented among the birds landing nearest to the observer, while in the fourth flock there was no such difference (χ^2_1 , two-tailed)."

Discussion: Page 164

"Individual birds in flocks had very different social rank, and according to my observations JUV were at the bottom of the dominance order. Social inferiority will add to their foraging difficulties due to sheer inexperience, for even though the JUV birds were not robbed of significant amounts of food, the frequent attacks from socially superior birds obviously interfered with their foraging activity. This probably explains the fact

that when on their own (flocks 15-21) JUV birds acquired more food per time unit than when in the company of AD (flocks 1-14, see Tab. 1). There is evidence to show that subdominant birds tend to have higher mortality rates than dominant ones (Fretwell 1969, Swingland 1975, 1977, Baker and Fox 1978), though this has not been examined in the blackheaded gull. This elevated mortality rate is probably due to social inferiority reducing access to critical resources. In stable social situations the elimination of the socially lowest ranked birds may be one of the selective advantages of hostile behaviour (Rohwer 1975). But it seems doubtful whether this mechanism could be operating in the gull flocks which were observed during the migratory period when flock composition probably changes rapidly."

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Human Disturbance (p. 5)

"A serious danger to nesting seabirds is disturbance by people, including scientists, bird-watchers, recreationalists, and others. Disturbance is usually unintentional and, more often than not, the culprits are unaware of the harm that they have caused. When people go into or near a seabird colony they can cause disturbance in many ways. An awareness of potential problems can do much to reduce disturbance."

"Flushing birds from nests must be avoided since it can cause adults to abandon nests, exposes eggs and chicks to predators, and interferes with incubation and the feeding of chicks. During panic departures adults may even break eggs or kick eggs and chicks from nests. Larger chicks may run off and, unable to get back to the nest, may die or be killed. Airplanes, boats, and helicopters, as well as individuals on foot, can cause birds to flush by approaching a colony too closely. Helicopters are especially disruptive."

"In California, predation on uncovered eggs and chicks is primarily by Western Gulls and Common Ravens (*Corvus corax*). Both gulls and ravens patrol colonies in search of unattended eggs and chicks or for a chance to steal food brought in by parent birds. Under natural circumstances their success rate is low, but a colony from which adults have been flushed is 'easy pickings.' Plundering gulls may walk ahead of human intruders, pecking holes into eggs, or they may fly off with eggs to eat elsewhere (Anderson and Keith 1980). Gulls calling overhead attract more gulls and add to the panic of the colony (Anderson and Keith 1980). Western Gulls are formidable predators. They will consume young chicks whole, including chicks of their own species, and will even attack large 3 to 4 week old pelican chicks to obtain regurgitations or will remove the eyes, uropygial glands, and entrails, causing death (Anderson and Keith 1980).

"Incubation of eggs and chicks is a means of maintaining an optimum temperature for rapid development. Parents sit on and turn eggs to warm them and will shade eggs and chicks from the sun to keep them from overheating. If parent birds are kept off their nests for a long enough period of time, death of the young from hyperthermia (overheating) or hypothermia (overcooling) can occur. Shorter periods of neglect can extend the incubating time required for hatching."

"The most damaging type of human disturbance is physical alteration of habitat, since its effects are longterm, and in most cases irreversible. Whaler Island (325 045) near the Oregon border is not part of the Crescent City breakwater and is no longer used by nesting seabirds. Osborne (1972) estimates from historical records that 200,000 storm-petrels (Leach's and Fork-tailed Storm-Petrels), along with Western Gulls, Pigeon Guillemots, and Black Oystercatchers, nested on Whaler Island. Loss of this nesting

island may have substantially reduced the number of nesting Leach's and Fork-tailed Storm-Petrels in California."

"Several seabird species nest in burrows dug into the ground. No one should walk on these burrow areas since they can easily collapse under the weight of a person. Birds may then abandon the burrow."

"Any disturbance to burrow-nesting species would be particularly unfortunate."

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The impact of roads on the densities of four bird species in an open field habitat--evidence of a long-distance effect. *Biological Conservation* 18:299-321.

Author's Abstract

Roads may affect animal communities in various ways. One such way is 'disturbance'. i.e. emission of stimuli to which animals may respond by avoiding the vicinity of the road. The extent, intensity and mechanism of this effect is almost entirely unknown. Veen (1973), studying the bird species lapwing *Vanellus vanellus*, black-tailed godwit *Limosa limosa*, oystercatcher *Haematopus ostralegus*, redshank *Tringa totanus* and ruff *Philomachus pugnax* in open grassland areas, found disturbance over surprisingly long distances, ranging from 500-600 m for a quiet rural road to 1600-1800 m for a busy highway. However, his approach has met with serious methodological criticism.

The validity of Veen's conclusions was tested by critically reanalyzing bird distribution in one of his study plots. It is inferred that his conclusions do hold for the lapwing, the godwit and possibly the redshank, though not for the oystercatcher. An additional field study in four areas yielded similar results, with comparable disturbance distances. The total population loss over this distance may amount to 60%. Rough indications were obtained that the distance-density graph is a logistic on 3, while the relation between traffic volume and total population loss is possibly logarithmic. In addition confirmation was obtained of the general impression that, apart from roads, disturbance may also be caused by farms, other buildings, and plantations, suggesting that disturbance caused by a road is not easily eliminated by planting trees alongside.

It is recommended that extra care be taken in planning new roads, while impact statements concerning roads which disregard disturbance and other long-distance effects of the fauna should be rejected.

Introduction

"During the period 1970-75 in the USA alone more than 3000 Environmental Impact Statements were made on transportation, most of which concerned highways (Council of Environmental Quality, 1976). This enormous number of EISs would suggest a vast amount of accumulated information of effects of roads on the environment. However, both the survey of Sullivan & Montgomery (1972) and our own brief survey of some recent EISs reveal that this holds true only for a few categories of effects, like pollution, noise, traffic victims and habitat loss. These topics have also been dealt with in detail in review articles (De Pienaar, 1968; De Soet, 1969; Van der Maarel, 1972; Oxley et al., 1974; Udo de Haes, 1975). Other effects have hardly been studied.

In order to clarify the position of this study, it seems useful to give a classification of the relevant effects. The first distinction that can be made is one between the effects of the road per se and those of the human activities upon it (management, traffic). Since these effects cannot easily be separated, this distinction is of little practical value. A more significant distinction is that between primary and secondary effects. The road/traffic complex not only has a direct environmental impact, but it may also enhance other human activities such as recreation of settlement of plants, thus secondarily causing environmental effects. This article deals with the primary impact of the road-traffic complex.

Emission of energy (noise, vibration, visual stimuli) may cause animals to avoid the vicinity of the road when selecting nesting and feeding sites. Population losses which may result both from avoidance and from traffic accidents can be expected to enhance the chances of island effects.

This article deals with the poorly investigated effect of the depression of animal densities in the vicinity of roads through emission (stimulus) and avoidance (response). We call this effect disturbance. We shall not go into the mechanism of disturbance—eg. into the problem of the nature of the stimuli to which the animals react: acoustical, mechanical or visual—but merely into its intensity as a function of the distance from the road.

When one such rich area was threatened in 1973 by a proposal to build a road, a number of biologists took action, and began a study of comparable areas situated next to roads. By studying density as a function of distance from the road, they hoped to find empirical support for their hypothesis that the biological effects of a road are much greater than one would expect from its area alone, thereby supplying an additional argument for not constructing the new road. Indeed, Veen (1973) found surprisingly long disturbance distances, varying between 500–600 m for a quiet rural road and 1600–1800 m for a busy highway. However, his study has met with serious methodological criticism."

Discussion

"Summarizing, it seems that our postulate of a density-depressing effect of roads holds strong for at least two species. However, this conclusion does not necessarily imply that population sizes are affected. One might argue that the populations merely alter their distribution, without growing smaller. Stated otherwise, a decrease in density near the road might be compensated for by an increase at further distance. This explanation, however, clashes with the concept of carrying capacity, which implies that, except for temporary depressions and for islands or comparable ecologically isolated communities, habitats are to be looked upon as being ecologically saturated. Of course this saturation might be less obvious in the case of species forming breeding colonies, but our meadowbirds have combined feeding-nesting territories. Nevertheless, Beintema & Van den Bergh (1977) and Mulder (1972) found in non-disturbed areas that meadowbirds show a somewhat clumped distribution. They do not explain this from the heterogeneity of the habitat, but from the tendency to form 'colonies' of territories. This interpretation gives way to the possible existence of suitable unoccupied habitat between clusters, into which the clusters may shift in the event of disturbance. This possibility can only be tested by further research, including population counts both before and after road construction over large areas, including a control.

Compensation might not only be found in higher densities (at further distance), but also in higher production. If we assume density-dependent production, the lower density adjacent to a road might lead to an increased breeding success in that area. However, if the road effect is brought about by avoidance, increased per capita production will only temporarily increase the population and will not lead to a higher breeding pair density in the following year (assuming, again, saturation at

further distance). Moreover, disturbance might also operate, at least in theory, through reduction of the breeding success, although we do not consider this very plausible (unless in terms of ultimate factors).

Disturbance will be especially important in open field habitats. However, we do not expect this effect to be simply eliminated by planting walls or trees alongside the road, since such objects only partially reduce emissions. Moreover, they themselves may act as sources of disturbance. Perhaps the effect might be reduced by constructing the road below ground level, but this would tend to reinforce the hydrological effects.

Considering all this, we would recommend:

1. that impact statements concerning roads which disregard long-distance effects be rejected; and
2. that extra care be taken in planning new roads, not merely in deciding how to construct them, but primarily in deciding whether or not to construct them."

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ADDENDA to 1984 AVIAN ENERGETICS

1. Energetic costs of "normal" activities and those associated with harassment.
2. Measurement of time-energy budgets in birds.
3. Rechanneling of energy with resultant reduction in reproductive output.
4. Disturbance affecting body condition of adults and then indirectly survival of progeny.

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"The frequency of heartbeats was measured in frigate birds, blue-footed boobies, waved albatrosses and swallow-tailed gulls. The measurements show that the heartbeat rate doubles or increases four times above the normal rate when visitors approach the birds within 18 m. The conclusion is drawn that the so-called "tame" Galapagos animals may be under high stress although this is not noticed by the observer. This may influence the breeding of these birds negatively. It is recommended that visitor trails should pass the frigate bird and booby colonies at least at 10-15 m distance and albatross colonies at 20 m distance. People should not approach single birds which breed outside the colonies within less than 5 m. These birds form a buffer between the visitors and the colony which should be maintained."

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Aspey, W.P. and S.I. Lustick (eds.). 1983. Behavioral energetics: the cost of survival in vertebrates. Ohio State Univ. Press. Columbus, Ohio. 300 pp.

Review by A. Kacelnik (In Ibis 126:261)

One of the most important contributions of the optimality approach to the study behaviour has been to point out profitable links between ethological and physiological research. This book, resulting from the Seventh Annual Biosciences Colloquium held in Ohio in 1980, is a fair reflection of this contribution. The importance of accurate information on energy costs for the understanding of behaviour is shown in a number of areas, including migration, reproduction, foraging, and behavioural thermoregulation. Being a collection of independent papers, there is some heterogeneity in approach and rigour. For example, while Wolf and Hainsworth (Ch. 8) reflecting the current views of most workers in optimal foraging, state that the extent of the correspondence between feeding and fitness may relate to variables ancillary to feeding, like predation and mating, Crowther and Magnuson (Ch. 7) unfoundedly attribute to optimal foraging theory the belief that animals should always maximize intake rate even ignoring energy costs. These authors present an interesting case of optimal foraging in fish, pointing out that if the environment is heterogeneous both with respect to food availability and temperature, maximization of net rate of gain will sometimes result in the fish foraging in areas where capture rate is not maximal and temperature is different from that chosen when food is not limiting. This is a perfectly orthodox use of the optimality approach, and the idea is also present in Lustick's (Ch. 9) analysis of the costs and benefits of thermoregulation in birds, but the authors introduce a terminological red-herring by claiming the victory of their 'Bioenergetic' model over two supposed alternatives: 'behavioral thermoregulation', which they claim will predict choice of temperature regardless of food availability and 'optimal foraging' which they claim to predict choice of area on the grounds of food only, regardless of associated energy costs. There is always some risk that these incorrect attributions may mislead newcomers to the field. Overall, the book is a useful contribution to any zoological library, and I hope that ideas presented in several chapters will make clear the need for detailed inclusion of physiological considerations when modelling behaviour.

Drent, R. H., and S. Daan. 1980. The prudent parents: energetic adjustments in avian breeding. *Ardec*, 68:225-252.

Perspective P. 246-248 (Energetic cost of "extra" activities)

In this review we have been concerned with the problem of how individual parents adjust their reproductive effort in order to maximize fitness. The adjustability of laying date, clutch size, pattern of egg care, and after hatching the level of provisioning and the composition of the diet implies a succession of decisions allowing an adjustment of parental capacity and environmental opportunity. Although we are far from understanding the pattern in detail, we have argued that energy balance is a good candidate for the substrate of decision. Put in other terms, we believe present techniques make the exploration of the proximate control of avian reproduction a promising avenue of research if we are to gain insight in the information relied on by the birds themselves in reaching their decision.

Problems concerned with initiating a breeding attempt, and details of timing and the determination of clutch size, have been discussed with an emphasis on the pervasive importance of female body condition. The difficulty here is not in conceptualizing how condition impinges on breeding performance for which good circumstantial evidence exists (see reviews by Korschgen 1977 and Newton 1977), but rather in obtaining meaningful indices of body condition. Most data are restricted to total body weight and there is a great need to design techniques enabling assessment of body reserves without sacrificing the bird. Perhaps small tissue samples from the pectoral muscle will prove adequate to follow changes in the protein bank, and it should be possible to estimate the state of fat reserve from blood samples, but these are problems for the biochemist.

Supplemented by more indirect estimates of energy expenditure derived from time budget observations, the available data do indeed suggest that a general energetic upper level for sustained work exists. Although it would be premature to conclude that the optimal working level has indeed been defined in metabolic terms, these estimates do open the possibility that parent birds reach their decision on how far to invest in their current brood by monitoring energetic exertion. The implication is that work beyond 4 B.M.R. on a daily basis cannot be sustained without impunity, either because the parent cannot physically keep up (and hence would be forced to cut back its effort drastically in order to recover) or because exertion beyond this level is detrimental to parent survival. In any case it appears that the "optimal working capacity" postulated by von Haartman (1954) and Royama (1966b) has an empirical basis approachable with physiological techniques along the lines applied to human subjects at work.

A complicating factor is the extent to which parents buffer environmental events by anticipatory deposition of reserves. This is commonly observed prior to laying in females and is also a common tactic during incubation, yielding added flexibility in matching daily demand and daily intake in the nestling phase. Identifying a period of energetic surplus does not "explain" the formation of reserves, but rather demands detailed investigation on why energy-costing processes are not put in motion without delay.

Summary P. 248

1. Energetics of reproduction in birds is reviewed with the question in mind how the parent adjusts its effort in relation to prevailing environmental conditions in order to maximize the output of young in its lifetime. Emphasis is on proximate controls, rather than ultimate factors measurable in terms of adult survival and recruitment of young.
2. The decision to breed or not to breed is clearly related to body condition of the female, presumably because of the implications this has for survival.
3. Laying date and clutch size are likewise under the influence of female condition and can hence be modified by experiments involving supplementary feeding (Fig. 2,3). Natural variation in these features may often be related to territory quality.
4. Implied in Lack's view of brood size is a limitation of parental foraging capacity, and the last section of the paper is devoted to exploration of the proximate factors delimiting what Royama terms the optimal working capacity of parents feeding young. Observations of parent starlings confronted with manipulated brood size suggest a limit on the time that can be devoted to energetically extravagant flight activity, rather than a shortage of absolute time. Beyond the limit to which stressed parents can be made to fly, body weight declines.
5. Preliminary data on energy metabolized daily by parents confronted with large broods conforms to the simplified view that parental effort on a sustained basis equates to energy mobilization equivalent to 4 B.M.R. units and it is suggested that this level of energy expenditure represents a proximal decision substrate for determining the optimal working capacity of the parent.

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Geist, V. 1971. Is big game harassment harmful? Oilweek 22(17):12-13.
June 14, 1971.

"In the recent past, voices have been heard expressing concern about the effects of aircraft harassment on big game in the north. With increased exploration in the Arctic, it is natural that more explorers will take a closer birds'-eye-view of big game below, and possibly fly down very close for picture-taking. Is this really harmful to wildlife? Is a concern for harassment governed by emotion, any no more valid than a suggestion that we might run out of oxygen in the atmosphere if we burn all the fossil fuels of the earth? Unfortunately, there is substance to the harassment claim."

"One cannot fully appreciate the effects of disturbance on big game animals without understanding their biology throughout the yearly cycle; their physiology of pregnancy and of stress; and their ability to learn and respond, on the basis of their past experience. Even so, a number of effects are perfectly understandable to a non-biologist. At the very least harassment only raises the cost of living to the animals, which in turn must be drawn from the ranges inhabited by them; at worst it can cause their death. A somewhat crude example will make this plain."

"A ruminant, such as a caribou or sheep on a medium-plane diet equivalent to very good hay, takes in about 145 kilocalories of metabolizable energy or about 80 grams of fodder per $\text{kg}^{0.73}$ of body weight per 24 hours. Mild excitation, during which the animal does not run, costs about 25-30 kilocalories $\text{kg}^{0.73}$ per 24 hours or 1.0-1.4 kilocalories per $\text{kg}^{0.73}$ per hour, above and beyond normal daily expenditures. Assuming a winter day with little wind, and temperatures above -20°F ., and normal cost of existence is probably about 5 kilocalories $\text{kg}^{0.73}$ per hour. Exertion, such as fast, sustained running by well-trained animals costs about 1,400 kilocalories $\text{kg}^{0.73}$ per 24 hours or nearly 1 kilocalorie $\text{kg}^{0.73}$ per minute. Steady, fast walking over rough terrain costs about 0.4 kilocalorie $\text{kg}^{0.73}$ per minute."

"With this information one can calculate the minimum cost of energy, forage or body fat to a caribou weighing 90 kg, which was chased and ran for 10 minutes, then walked for 1 hour and remained excited for another hour. Such an exercise costs the caribou about 665 kilocalories above and beyond the 3,200 it expends during the day to stay alive. This is a jump in the cost of living of almost 21%, and about 3% more than the animal's total possible forage consumption. Since this additional cost of 665 kilocalories will be drawn from the energy stores of the animal, it represents about 74 grams of body fat oxidized. It takes between 1,300 and 1,600 kilocalories of metabolizable energy--depending on forage quality--to synthesize 74 grams of fat, or about 2 pounds of good forage. Thus, running a herd of 100 caribou, assuming they behave in the manner described, would cost a minimum of 200 lbs. of forage."

"Is this serious? As a single incident--of course not; but if it is repeated often enough then it becomes another story. Energy loss is, after all, the least worry, although 10 harassments of the type described

described do cost an extra ton of dry forage, and this has to be grown somewhere."

"Harassment can be most detrimental at critical times. For caribou or moose these critical times are the fly season, very cold weather in late winter, late pregnancy, and calving time. Exertion during cold weather, particularly of weakened animals, is likely to precipitate emphysema and kill the animal. In fact, excessive running during any time of the year may have this consequence, and Russian scientists report these effects in chased reindeer, moose, and saiga antelope."

"Chasing heavily pregnant females through deeply crusted snow (which causes them to strike their bellies on the snow crust or against hidden obstacles) is likely to precipitate abortion, and has been documented for reindeer. Abortion can also result from chasing pregnant females over snowless ground for long distances. Even if no abortion takes place in females near term, the fetus can be displaced resulting in difficult birth and death of the fawn at best, and in the death of the female at worst."

"Harassment of reindeer at calving time causes trampling or desertion of fawns, and there is reason to believe that it needlessly increases predation of fawns as well. The effects of an aerial picture-taking expedition--low over a herd of calving caribou females, half calved out, the others with small, weak fawns--can be left to the reader's imagination."

"Harassment is particularly damaging when the animals are in poor condition, which for caribou is during fly season. Russian reports indicate that a reindeer may lose up to 125 cc of blood to mosquitoes during a day. The animals are restless, many are anemic, some die. Their digestive processes are at times interrupted due to a cessation of HCl secretion in the true stomach. Additional stress placed on the animals may cause an outbreak of necrobacillosis. When a group of caribou is seen, having taken refuge from flies on a high snowfield, they should be left in peace. Their life is tough enough as it is."

"There is more to harassment, but it all points to the same conclusion: it does little good for the wildlife. It may seem peculiar to the uninitiated, but there would be less harassment if all aircraft were to buzz big game unfailingly, than just the occasional time. Mammals easily become accustomed to predictable events that are at first scary, but are not followed by painful events. Thus big game get used to highway traffic and ignore it, despite the noise, stench, and fast--but predictably moving--objects."

"Unfortunately, animals excited by any stimulus at unpredictable intervals begin to grow excited when they hear or see unpredictable stimuli. Excitement costs energy--vital energy needed for survival in winter or for the growth of the fawn, calf, or lamb inside the female. Excitement raises mild havoc at first--serious havoc if chronic--with the hormonal

system, and in turn adversely affects the growing embryo. It is now known that a 17% loss in body weight early in gestation causes reindeer females to resorb young. Harassment, added to natural stresses, can press weight loss below that limit."

"Yes, the evidence is largely circumstantial. Would one wish to compile hard, fast, and irrefutable data by testing how far 100 (a sufficient sample size) caribou females have to be run in April before they all abort, collapse, or die of emphysema?"

Goss-Custard, J.D. 1979. Effect of habitat loss on the numbers of overwintering shorebirds. *Studies in Avian Biology* 2:167-177.

Author's Abstract

This paper discusses issues raised by attempts to predict whether the numbers of shorebirds using an estuary will decrease following industrial, agricultural, or recreational development of some of their feeding grounds. Within an estuary, most feeding is usually done in limited parts of the shore where the prey are most abundant. Hence, the siting as well as the size of a development scheme is important in evaluating its effects on particular shorebirds species. Bird densities may be highest in those estuaries where prey densities are highest but it is not clear if this reflects a simple behavioral preference of individuals for the best feeding areas or results from disproportionately high mortality rates, or subsequently low reproductive output, in estuaries where food is scarcest, or is due to a mixture of both. Hence studies need to be designed to see if a loss of feeding grounds will lead simply to a redistribution of birds over the feeding grounds or to a reduction in overall numbers. Observations suggest that bird density may reach a ceiling level in preferred areas so that a loss of habitat would cause more birds to feed in the less favored areas or even to leave the estuary altogether. However, some increase in numbers in the preferred areas that remain may nonetheless take place. Several indirect lines of evidence suggest that food shortage may be a contributory factor to winter mortality, especially during very cold weather. Field studies indicate that all the ways in which birds might respond to a loss of feeding grounds within an estuary would reduce the rate at which they can feed and so exacerbate any food shortage. Some of the difficulties in predicting the effect of a loss of feeding areas on shorebird numbers are discussed.

Concluding Remarks (Re: Disturbance of birds: Flushing from preferred feeding grounds)

"To conclude, where food shortage is already a contributory factor to winter mortality and an increase in bird density is likely to occur after part of the habitat is removed, a reduction in the feeding grounds seems likely to make an already difficult situation worse. This is because all the ways in which the birds seem likely to respond to the changed circumstances would reduce the rate at which they can feed. First, packing into the preferred feeding areas which remain, assuming that this is in any case possible, would reduce food abundance and may decrease feeding rate still further through increased interference. Second, feeding more in the less favored parts of the shore would mean that the birds would feed less profitably. Third, feeding on a wider range of size classes of prey would probably lead to a reduction in ingestion rate because the birds may already select the prey sizes which maximize the rate at which they collect food (Goss-Custard 1977c, this volume)."

"The reliability of this approach to making predictions about the effects of a loss of habitat on bird numbers depends a great deal on the evidence that birds already experience food shortage, and this is not easily obtained in short-term environmental impact studies. Furthermore, the degree to which food scarcity is a contributory factor to mortality is likely to vary both between estuaries, because food abundance varies considerably (Goss-Custard et al. 1977b), and between species within the same estuary. Hence each situation has to be examined in depth. One advantage of the approach is that it is unlikely that birds would be able to respond successfully to the reduction in food supplies: Hungry birds would be expected to have already tried all available means of securing enough food. A disadvantage is that the approach fails to predict by how much survival and reproductive rates might be affected by a loss of feeding grounds. Furthermore, problems arise where food shortage does not occur at present. In such cases, it is necessary to predict at what point survival and reproductive rates will be affected by successive reductions in the food supplies, and whether or not birds that leave the estuary could utilize new grounds further into, or even beyond, the existing winter range of the population. Such difficulties underline the extent to which our present attempts at prediction need to be improved."

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Horstman, L. 1981. Effects on Wildlife. Noise stress might sometimes be the last straw. Environment Views 4(3):30-31 (Alberta Environment, Edmonton).

Notes

"Filing slowly across the barren mountain slope, the group of Dall sheep descended toward the Canning River valley.

Near their destination, the extensive mineral lick at the top of the valley, the lead ewe halted. A loud noise from the vicinity of the lick shattered the arctic morning stillness. The group hung back nervously, the sound persisted. The ewes lay down on the trail and waited.

Some 250 kilometers to the east, between the northernmost slopes of the Yukon's British Mountains and the Beaufort Sea, a large flock of snow geese approached the marshy coastal plain. Used for centuries by countless numbers of waterfowl, this isolated area served as a staging ground where birds could rest and feed before their southward migration. Spotting decoys in the area, the geese spiralled downward. But didn't land. A strange noise emanated from the vicinity of the decoys. The flock wheeled sharply and departed.

Thus began two of the first and only experiments to study the effects of noise, apart from any visual stimulus, on wildlife.

The year was 1972. The Canadian Arctic Gas Study Ltd. and Alaskan Arctic Gas Study Co., groups formed to study the feasibility of a gas pipeline from Prudhoe Bay, Alaska through the Yukon to the Mackenzie River and thence south into Alberta, were faced with one of many environmental questions: how wildlife in the remote parts of the route would react to the noisy 20 and 30,000-hp gas compressor stations that would be needed every 80 kilometers along the pipeline. Would animals avoid these areas permanently or temporarily or would they become accustomed to the noise?

And yet, in the goose-simulator study, significantly fewer flocks landed to feed and significantly more flocks changed their direction of flight when the simulator was operating than when it was silent. Some flocks feeding as far as 4.8 kilometers away departed when the simulator was turned on. The consulting biologists conducting the test concluded that "if optimum goose areas cannot be avoided when building the (compressor) stations, then either the stations should be shut down during the staging period, or an efficient muffler system should be incorporated."

That's birds, some might argue: flighty by nature. But look at these findings: pigs, exposed to 130 dB of 300-600 Hz noise for 15 second intervals show an increase in heart rate after the fourth repetition; taped aircraft noises played to hens at 120 dB for eight out of every 20 minutes cause them to stop incubating eggs; while (randomly generated) noise played at 100 dB to domestic lambs causes a significant rise in heart and breathing rates.

These and other experiments were conducted in various laboratories by many researchers in attempts to understand the physiological effects of noise. Some of the experiments were more remarkable for their choice of treatment than for their results; for example, cows were subjected to the sound of exploding paper bags every few seconds during milking (with predictable results on milk production).

The gist of the findings soon became clear: noise can definitely exert stress on animals. Its effects may not be visible on the animal's behavior, but are measurable in endocrine output and resulting physiological and sometimes even reproductive changes.

For wildlife individuals or populations, an additional stress coming at a time of high naturally-occurring stresses such as a severe winter or fly season, can be the last straw. Also, there may be times when noise is more of a stress than at other times, for example in spring, when females with young are often more sensitive to disturbance.

As Bergerud points out, the strongest response-evoking sounds are those which have traditionally been important to the animal in its natural environment. These biologically meaningful sounds would include those made by the species' predators, other natural danger signals (such as ice cracking), and intra-specific communication sounds for a variety of purposes—mate-calling, territorial defence, and so on.

The idea of biologically significant sounds may also explain why the low hum of transmission lines is reportedly disturbing to the semi-domesticated reindeer herds of Norway. According to Dr. R. Klein, herders have difficulty driving the herds under such lines. Perhaps the sound is reminiscent of the swarms of flies which plague the species in summer.

Given enough time, animals are capable of learning the significance, or lack thereof, of infrequent man-made noises. Propane-driven scare cannons, used to keep elk and deer away from crops and haystacks, lose their effectiveness after a while. The learning is probably fastest when such noise is associated with adverse consequences, such as the sound of vehicles and hunting. Will fish, within whose hearing range falls the underwater sound of commercial fishing vessels, learn to avoid these sounds?"

Kanwisher, J.W.; T.C. Williams; T.M. Teal and K.O. Lawson Jr. 1978. Radio telemetry of heart rates from free-ranging gulls. *Auk* 95:288-293.

Author's Abstract- A lightweight radiotelemetry system with a range of 80 km was used to monitor heart rate from free-ranging Herring Gulls on flights of up to 20 km. Heart rate varied from 130 beats/min in a resting bird to 625 beats/min for sustained flight. Soaring birds showed rates similar to those of birds sitting quietly on the ground. Simultaneous records of telemetered heart rate and intraspecific conflict on the nesting island revealed that cardiac acceleration preceded overt visual communication. Intensely aggressive behavior was accompanied by heart rates approaching those of sustained flight. Heart rate as a measure of metabolic cost indicates that the gull's behavioral adaptations for long-distance flight, food location and intraspecific communication result in major energy savings.

Discussion

"Bird flight is unparalleled in animals for its sustained high energy expenditure (Tucker 1969, 1972). A single overwater flight may burn half of a bird's weight in the form of stored mobile fat (Odum 1960, Nisbet et al. 1963). Although data are at present limited, heart rate appears to be a relatively good predictor of metabolic rate in birds and mammals (Johnson and Gessaman 1973, Gessaman 1973b). Gulls are apparently able to reduce the cost of airborne travel greatly by soaring; the heart rate of a soaring bird is similar to that of an alert bird sitting quietly. Such data support the generalization that laboratory measurements of the metabolic cost of flight may indicate only maximum rates, while free-ranging birds often require less energy to cover a given distance. Gulls appear to have some latitude even during steady flapping flight, as we monitored heart rates from 480-625 beats/min during powered flight. Such changes may reflect variation in the amplitude of wingbeats, which we have often observed in gulls flying near ships."

The evolutionary advantage of complex signaling behavior in gulls (Tinbergen 1972) is also apparent in studies of telemetered heart rate. Intense, aggressive interactions between conspecifics are accompanied by heart rates approaching that of flapping flight; any communication systems that reduce such interactions must constitute a significant energy saving."

"As suggested by Gessaman (1973b), telemetered heart rate offers a technique to evaluate specific components of an energy budget in free-ranging animals. We believe such systems will also be of use in studies of respiratory physiology and behavior, but only if the telemetry system is designed for long-range, narrow bandwidth field use. FM systems designed for laboratory or hospital biomedical research appear ill-adapted to this purpose. The ability to monitor both physiology and naturalistic behavior in field studies offers great promise; one or two sensors certainly are not going to reveal the inner workings of an animal, but they help considerably."

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CONTROL OF BIRDS, BIRD SCARING, PROTECTING CROPS,
DISPLACING BIRDS FROM FIELDS OR WATER

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Boag, D.A. and V. Lewin. 1980. Effectiveness of three waterfowl deterrents on natural and polluted ponds. *J. Wildl. Manage.* 44(1):145-154.

Author's Abstract

In 1975, 3 types of waterfowl deterrent (a model falcon, a moving series of reflectors suspended from a frame, and a human effigy) mounted on floats, were tested for efficacy in deterring waterfowl from entering a series of small natural ponds in the boreal forest of Alberta. Only the effigy appeared to be effective; diving ducks of the genus *Aythya* were affected most. In 1976, the human effigy was tested on an artificial tailings pond that received aqueous and bituminous effluent from an oil sands extraction plant near Fort McMurray, Alberta. Twenty-seven effigies were deployed over the 150-ha pond. Their effectiveness was judged by comparing the number of waterfowl dying in and associated with this pond in 1975 (without deterrents) with number dying in and associated with it in 1976 (with deterrents). Kill figures in 1976 were significantly lower than expected on the basis of relative abundance of birds in the 2 years. We concluded that this decline was due to the presence of the effigies.

Introduction

"An ability to deter waterfowl from using aquatic habitats that have become potentially lethal, either through disease organisms such as botulinum or chemical pollutants such as petroleum in its various forms, has become a major concern for agencies and individuals managing waterfowl. Detering ducks and geese from such areas, particularly when they encompass locations where these birds concentrate while migrating, molting, or nesting, are largely untried (Davis et al. 1974)."

"We tested 3 types of bird deterrents. In this report we record their efficacy in preventing waterfowl from entering natural and artificial ponds in the boreal forest of Alberta."

Methods

"The human effigy was a clothed commercial manikin. The clothes consisted of bright orange coveralls and a knee-length bright yellow plastic raincoat. The manikin was bolted to a platform and steadied with guy wires. As with the other deterrents it was held at mid-pond position by means of ropes."

"In 1976 we retested the human effigy, the most effective of the 3 deterrents, on a tailings pond that received both aqueous and bituminous effluent from an oil sands extraction plant. We chose this pond (150 ha) because we knew that birds were dying in it as the result of bitumen fouling (Smith et al. 1975). In view of the apparently limited effective radius of the effigy, we had 27 of them placed evenly over this pond by 22 April 1976".

"Our approach in evaluating the effectiveness of the human effigy in deterring waterfowl from entering the tailings pond was a comparative one. We postulated that the presence of the deterrents would reduce the number of birds becoming fouled in these waters. To test this hypothesis we compared

the number of birds found dead or dying in this pond in 1975 before deterrent installation with the number found in 1976. Such an approach was valid only if we could show that any change between years in numbers of birds found dead was the result of the treatment and not some extraneous factor such as a change in the numbers of birds exposed to the pond. Furthermore, we had to know that the remains of birds found in the pond represented birds dying in that year."

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See for other views

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Bird Dispersal P. 120-121

"Bird dispersal involves harassing or frightening birds so that they leave, and do not fly around the runways. Methods of bird dispersal include auditory, visual, and chemical, scaring devices - usually employed by trained personnel deployed in vehicles.

Auditory dispersing devices, such as distress calls, 'shellcrackers', cannons, synthetic sounds, and ultrasounds, are used to frighten birds to leave the area. Most birds have distress calls which they use in communication with conspecifics to indicate danger or distress. Conspecifics usually respond by flying around the signalling bird, and then dispersing from the area (Kuhring 1963a, 1963b; Bushnell & Giban, 1968; Murton & Wright, 1968). Airport personnel use tapes of distress calls, and play them from loud-speaker systems on top of mobile vehicles, 'broadcasting' to birds loafing on runways. Such units are thus able to go wherever the birds appear to constitute a problem.

Shellcrackers and cannons are explosives that can be detonated at irregular intervals to scare birds. Shellcrackers are used from stationary or mobile units and can be directed at birds. Synthetic sounds may also be produced by machines, attempts being made for example to imitate and amplify natural sounds; they may be played to birds from mobile units, to disperse them. Ultra-sounds have also been used, but birds do not appear to respond to them (Thiessen & Shaw, 1957; Murton & Wright 1968).

In general, auditory dispersal methods are successful under a variety of conditions, but only when their use is varied to avoid habituation (Brough, 1968; Jong, 1970; Thomas, 1972; Blokpoel, 1976; Doughty, 1976). The 'startle response' is the sudden flushing of a bird on hearing any strange sound. In general, the time required to adjust to such sounds (habituation) varies from 1 hr to 5 days (Boudreau, 1968). Thus it is necessary to vary the stimulus (see below), and to reinforce it with occasional killing of some flock members (Paulkner, 1963; Brough, 1968; Blokpoel, 1976). Gulls rapidly become habituated to distress calls (Thomas, 1972), although the use of interspecific distress calls* can avoid rapid habituation (W.R.P. Bourne in Murton & Wright, 1968).

Most auditory methods (distress calls, shellcrackers, cannons, etc.) are successful only when they are moved periodically, and when their use is varied (Brough, 1968; Mattingly, 1976). Few procedures have been adequately tested, but Brough (1968) reports on tests using distress call tapes alone, shellcrackers alone, and tapes with shellcrackers. For gulls and corvids (crows, etc.), distress calls alone were more successful than shellcrackers alone, and together they were the most successful. For Starlings, the tapes alone were less successful than the other two procedures, whereas Lapwings (*Vanellus vanellus*) responded best to the detonations, and equally to either used alone. Of the auditory methods, only distress calls, shellcrackers, and cannons, are successful and at all widely employed, although cannons are less frequently used as they are expensive, not very mobile, and cannot be used in cold weather."

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"For many years Silvereyes *Zosterops lateralis* have been a nuisance in the vineyards of southern Australia. During observations on their behaviour in Western Australia we recognized that the birds call continuously while they are feeding in the vines. This call has a frequency range falling between four and five kHz. It occurred to us that the birds might be disturbed if they were unable to hear other Silvereyes in the feeding area and that the broadcasting of a sound that totally enveloped that frequency range might be a cheap and convenient method of disturbing the birds sufficiently to prompt them to avoid the vines."

"In 1973 we developed an electronic device that emitted a filtered white noise covering the frequencies 3.5 kHz to 5.5 kHz. We tested this in commercial vineyards in the Swan Valley with encouraging results. We then modified it to produce a sweeping tone, covering the same frequency range, driven by the 50-Hz mains oscillation. This device was tested in a row of Early Madeleine grapes that had always been seriously damaged by Silvereyes in Mateljan's vineyard, West Swan."

"The vines on which damage was monitored composed six three-metre panels regularly spaced at nine-metre intervals along a row of Early Madeleine vines; the row had been planted at the edge of an orange orchard and was more than 200 metres from other vines. Figure 1 shows a diagrammatic plan of the area and the arrows indicate the direction from which the Silvereyes generally approached the vines. Nine non-directional speakers from which the noise was emitted were spaced at three-metre intervals in a twenty-seven metre length of the row shown by the hatching on Figure 1. The bargraphs in the Figure show the cumulative counts of damaged grapes made every two days from the six panels monitored. Many damaged grapes were found in the two unprotected panels, P₁ and P₂, few in the three within the protected area, P₃, P₄ and P₅ and few in the unprotected panel, P₆, cut off from the usual approach route of the birds by the protected zone."

"Two more trials were made and each time substantial protection of the crop was achieved. However, other tests in the field demonstrated that much still needs to be learnt about the most appropriate methods of installing the device to achieve maximum protection; installations will need to differ from vineyard to vineyard in relation to local conditions. We consider that this machine probably works in the way outlined at the beginning of this note and that the principle, i.e. jamming the communication frequencies of a bird, would apply only when the birds feed in a flock and maintain contact-calling during feeding."

"A fuller account of the development of this apparatus and the tests that have been made with it will be published elsewhere."

Review in Bird Banding 50(3):276

"Damage to grapes by *Zosterops lateralis* has long been a problem to grape growers in southern Australia. On the assumption that increasing numbers of these birds are attracted by the calls of birds first foraging in a vineyard, an attempt was made to jam the birds' communications by broadcasting in the vineyards a sound covering the frequency range of the birds' calls. Substantial reduction in damage to the grapes was achieved."

"Take heed research workers and administrators, much need exists for imaginative research such as that done by Knight and Robinson if we are ever to clear from our dinner tables food contaminated with chemical pesticides and repellents.--Paul A. Stewart."

Mott, D.M. 1978. Control of wading bird predation at fish-recovering facilities. Pages 131-132. *In* Wading Birds. A Sprunt IV, J.C. Ogden and S. Winckler. (eds.). National Audubon Society, New York, N.Y.

Physical Barriers

"Lagler (1939) reported also that a system of crossed wires placed about 61 cm. above the water eliminated predation by birds, including herons. However, Naggiar (1974) was not as successful in keeping birds other than gulls away from fish with horizontally placed wires. McAtee and Piper (1937) gave details for installation of an overhead wiring system in addition to discussing other methods of excluding fish-eating birds."

Frightening Devices

"Many devices have been used for scaring fish-eating birds. They include scarecrows, shiny tin reflectors, flashing lights, electric fences, sirens, fireworks, shooting and gas-operated exploders (devices operating on acetylene gas that explode at controlled intervals with a report resembling a 12-gauge shotgun). Naggiar (1974) found that foil flashers kept Great Blue Herons and other wading birds away from fish ponds. He found also that flashing lights with reflectors had at least short-term utility in keeping Great Blue Herons and night herons from foraging at night. Naggiar (1974) in Florida and Peacock (pers. comm.) in Idaho reported that gas-operated exploders were effective in preventing fish losses. Peacock noted that exploders were more effective against Great Blue Herons and Black-crowned Night Herons if the devices were moved periodically. Lagler (1939) listed shooting to frighten birds as a method of preventing fish losses. Both live ammunition and exploding projectiles (shellcrackers) have been used with varying degrees of success. Naggiar (1974) found that a single-strand electric fence around a pond showed some promise in providing protection. However, bird mortality was occasionally noted when using this technique. With either visual or auditory frightening devices, it is important not to let the birds become too accustomed to the stimulus. This can best be accomplished by occasionally changing the location or timing of the device. Combinations of devices used simultaneously usually are more effective than a single device used alone."

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Scaring waterfowl Pages 148-149

"Bird scarers have been used ever since man had trouble with bird depredations on his crops. The principle of effective scaring is to convince birds that danger threatens in the protected area. The simplest form of scaring device is the scarecrow, which may be a simple cardboard cut-out or a dummy made to look like a human. Scarecrows do not move, however, and birds quickly discover that they pose no threat. Other visual scarers such as revolving signs and balloons have sometimes been effective. Hochbaum *et al* (1954) scared ducks in Manitoba with the use of straw-filled bags swinging from the end of a long pole. The birds were presumably reluctant to land when an object was moving above them. A tethered gas-filled balloon can be just as effective for the same reason and the outline of a bird of prey is sometimes suspended underneath for even greater effect. A great deal of success has been achieved in Britain recently by using strips of coloured tape stretched on poles across a field. As much as 150 acres in a block have been protected from Greylags and Pinkfeet in the spring, but Barnacle Geese grazed underneath the strips after they had been in position for several months."

"Most geese are regularly shot at and associate the sound of shooting with danger. Many scaring devices reproduce the sound of shooting. Rope bangers (slow-burning ropes with fireworks placed at intervals along them) are effective for about a week, but the most popular bangers use exploding propane gas. The explosion takes place at the base of a long hollow tube or barrel, which amplifies the sound. Most bangers are more effective if explosions are irregular and the direction from which the sound comes is often changes. Occasional shooting reinforces the effectiveness of exploding devices."

"Undoubtedly the most intensive, expensive and determined effort at goose dispersal (though this was not only because of agricultural damage) was at Horicon Wildlife Refuge, Wisconsin (Reeves *et al*. 1968, Gilbert 1977). Following abortive attempts at drainage of the 30,000 acre (12,000ha) marsh for agriculture in the early twentieth century, it was acquired jointly by the state and federal governments and set aside as a wildlife refuge. The marsh was not usually visited by large numbers of geese but was along the migration route of *interior* Canadas from the Hudson Bay lowlands. Following the establishment of a flock of tame geese to decoy them, the wild birds were induced to use the refuge. By 1950 10,000 geese used the marsh and following improvements in surrounding habitats and the farming of the land for geese, numbers grew to 100,000 in the 1960s and 100,000 in the 1970s."

"The impetus for action came from surrounding farmers whose crops were increasingly being used by feeding geese, as well as from hunters in the birds' traditional wintering areas where wintering populations had been drastically reduced. The federal government decided to 'haze' the geese in an attempt to halve the marsh population. 'Hazing' involves continual disturbance by all means available to make the area as unattractive as

possible to the geese. At the height of the campaign in 1966 2 aircraft, one helicopter and 10 water and marsh vehicles as well as many exploders and other scaring devices were used. Thirty-nine people were involved in these efforts. While geese were discouraged from using the refuge during daylight, they returned to feed at night and used more fringe areas for feeding. None had apparently been induced to migrate further south and the population in the following autumn (1967) had increased by 25%, to 150,000."

"Even more determined efforts were made in 1976, including the partial drainage of the marsh to make it less attractive as a roost, and even more intensive hazing. More than half a million dollars were set aside for the project which was to continue for 3 or 4 years. Airboats operated in the remaining marsh channels day and night and 700 gas exploders were available for use on farmland. This campaign did not achieve immediate results, but it remains to be seen whether the dispersal efforts will be successful in the long term"

"This example illustrates how difficult are the traditions of geese to break and how tenaciously an adaptable species like the Canada Goose will adhere to a favourable area. One major factor in the hazing experiment was the quality of the feeding in the Horicon area. The geese spent very little time in gathering high energy cereals and consequently could collect their daily requirement even if moved frequently. Flying is costly in energy for geese but the costs can be easily made up if food is easily available and of good quality. Grazing species or rooters, which require much longer to collect their daily ration, would presumably be much easier to disperse by continual disruption of their feeding pattern."

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Attempts to develop acoustic methods of keeping cape fur seals
(Arctocephalus pusillus from fishing nets. Biological Conservation
21:141-158.

Abstract

Cape fur seals Arctocephalus pusillus cause losses to catches of pelagic shoaling fish made by purse-seine vessels off southern Africa. The seals disturb fish shoals and fish within nets, and damage nets. Weighted firecrackers, 'Thunderflashes', 'Belugas' and 'Seal Deterrents', that exploded underwater were used to scare seals in nets. Seals responded to playback of killer whale Orcinus orca vocalisations and sweep frequency pulses, but did not flee. Seals moved away from 0.303 in calibre rifle bullets fired into the water in their vicinity, but were unaffected by bullets fired over their heads. An arc-discharge transducer was developed to produce the underwater compression and sound levels similar to those caused by firecrackers and by 0.303 in bullets. Most seals did not leave a purse-seine net. It is concluded that deterrents developed in this study were ineffective in reducing disturbances by seals at purse-seine nets.

Discussion

Cape fur seals showed an initial alarm reaction to underwater playback of killer whale vocalisations and, to a lesser extent, to sweep frequency pulses, but did not avoid them. Several suggestions can be made for this lack of avoidance reaction.

Killer whale vocalisations have had varying effects on the species they have been broadcast to. They have produced avoidance reactions in jackass penguins Spheniscus demersus, gray whales and beluga whales (Frost et al., 1975; Cummings & Thompson, 1971; Fish & Vania, 1971), and have caused panic among dolphins (family Delphinidae) in seine nets of tuna fishermen in the eastern tropical Pacific Ocean (Pryor & Norris, 1978). However, when played back to southern right whales Eubalaena australis, they either produced investigative behavior or had no apparent effect (Cummings et al., 1972, 1974). They initially produced an avoidance reaction in a captive common seal, but the response gradually decreased, indicating that the seal had habituated to the sound (Anderson & Hawkins, 1978). Killer whale vocalisations did not disturb grey seals Halichoerus grypus or California sea lions that were attracted to a food source (Anderson & Hawkins, 1978; W. C. Cummings, pers. comm.).

Cape fur seals are likely to habituate to any deterrent which merely frightens them. Therefore a method of deterring seals which causes pain should be more effective. It is not yet known whether underwater sounds or compression waves of the strength used in this study actually

pain Cape fur seals or merely cause a sudden shock, but the latter is considered more likely.

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A modern poet writes:

"With each year there are more airplanes,
With each year, fewer cranes."

Re: Man and noise effects. Page 75
In Komarov, B. 1980. The destruction
of nature in the Soviet Union. M.E.
Sharpe, Inc., White Plains, N.Y.
150 pp. (Translation of the 1978
Book.)

"The most important science to develop now is the anticipation of the dangers of the transformations that we bring into our lives and into nature, so that we know where to stop For the first time in the history of human kind we ask ourselves before starting something:

"What will happen if we carry this too far?"

I have come to call that "adapting to the future". We are beginning to learn to anticipate through knowledge and imagination, what the consequences will be if we do certain things. If we cultivate that ability, then we will not go far astray.

René Dubos

Rockerfeller University

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